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Description

Technical Field of the Invention

5 [0001] The present invention relates to coated hard alloy blade members or cutting tools having exceptional steel and cast iron cutting ability for both continuous and interrupted cutting.

Background Art

[0002] Until now, the use of a coated cemented carbide cutting tool made by using either chemical vapor deposition or physical vapor deposition to apply a coating layer of an average thickness of 0.5-20 µm comprised of either multiple layers or a single layer of one or more of titanium carbide, titanium nitride, titanium carbonitride, titanium oxycarbide titanium oxycarbonitride, and aluminum oxide (hereafter indicated by TiC, TiN, TiCN, TiCN, and Al₂O₃) onto a WC-based cemented carbide substrate for cutting steel or cast iron has been widely recognized.

[0003] The most important technological advance that led to the wide usage of the above-mentioned coated cemented carbide cutting tool was, as described in Japanese Patent Application No. 52-46347 (JP-A-53-131 909) and Japanese Patent Application No. 51-27171 (JP-A-52-110 209), the development of an exceptionally tough substrate wherein the surface layer of a WC-based cemented carbide substrate included a lot of Co, a binder metal, in comparison with the interior, whereby the fracture resistance of the coated cemented carbide cutting tool rapidly improved.

[0004] In addition, as disclosed in Japanese Patent Application No. 52-156303 (JP-A-54-87 719) and Japanese Patent Application No. 54-83745 (JP-A-56-009 365), the confirmation that, by sintering the WC-based cemented carbide containing nitrogen in a denitrifying atmosphere such as a vacuum, the surface layer of the WC-based cemented carbide substrate can be made from WC-Co which does not include a hard dispersed phase having a B-1 type crystal structure, whereby it is possible to cheaply produce WC-based cemented carbide having more Co in its surface layer than in the interior, was also important.

[0005] Concerning the advancement of the coating layer, coated cemented carbides having coating layers wherein the X-ray diffraction peaks of the Ti compounds such as TiC, TiN, and TiCN have a strong (200) orientation and the Al_2O_3 has an α -type crystal structure such as described in Japanese Patent Application No. 61-231416 (JP-A-63-089 202) and coated cemented carbides having coating layers wherein the X-ray diffraction peaks of the Ti compounds such as TiC, TiN, and TiCN have a strong (220) orientation and the Al_2O_3 has a κ -type crystal structure such as described in Japanese Patent Application No. 62-29268 (JP-A-63-195 268) have little variation in the tool life.

[0006] Furthermore, Japanese Patent Application No. 2-156663 (JP-B-7-88 582) shows that a coated cemented carbide having a coating layer wherein the TiC has a strong (111) orientation and the Al_2O_3 is of the κ -type has the features that there is less spalling of the coating layer and has a long life.

[0007] However, since the Ti compounds such as TiC of Japanese Patent Application No. 61-231416, Japanese Patent Application No. 62-29268, and Japanese Patent Application No. 2-156663 are coated by the normal CVD method, the crystal structure is in a granular form identical to the coating layers of the past, and the cutting ability was not always satisfactory.

[0008] Additionally, Japanese Patent Application No. 50-16171 (corresponding to GB-A-1 489 102) discloses that coating is possible with the use of organic gas for a portion of the reaction gas, at a relatively low temperature. In this patent, the crystal structure of the coating layer is not described, and furthermore, the crystal structure may have a granular form, or the crystals may grow in one direction (elongated crystals) depending on the coating conditions. Moreover, in the references given in this patent, the coating layer is made up of only TiCN, and Al₂O₃ is not disclosed. Additionally, this TiCN had a low bonding strength with the substrate.

SUMMARY OF THE INVENTION

[0009] In recent years cutting technology has shown remarkable progress towards unmanned, high speed processes. Therefore, tools which are highly resistant to wear and fracturing are required. Consequently, the present inventors conducted research to develop a coated cemented carbide cutting tool having cutting ability of a higher level.

[0010] It was discovered that by coating the surface of a WC-based cemented carbide substrate and a TiCN-based cermet substrate with TiCN having crystals growing in one direction (elongated crystals) as an inner layer, and coating with Al_2O_3 having a crystal structure κ or $\kappa + \alpha$ wherein $\kappa > \alpha$ as an outer layer, remarkable steel and cast iron cutting ability was shown for both continuous cutting and interrupted cutting.

[0011] Thus, the coated hard alloy blade member as described in claim 1, in accordance with the present invention comprises a substrate formed of a hard alloy selected from the group consisting of a WC-based cemented carbide and a TiCN-based cermet, and a hard coating deposited on said substrate, the hard coating including an inner layer of TiCN having unilaterally grown crystals of an elongated shape and an outer layer of Al_2O_3 having a crystal form κ or $\kappa + \alpha$

wherein $\kappa > \alpha$.

BRIEF DESCRIPTION OF THE DRAWING

5 [0012]

FIG. 1 is a photograph of a coated cemented carbide blade member in accordance with the present invention as taken by a scanning electron microscope.

10 DETAILED DESCRIPTION OF THE INVENTION

[0013] The coated hard alloy blade member or cutting tool in accordance with the present invention will now be described in detail.

[0014] As mentioned before, the coated hard alloy blade member in accordance with the present invention comprises a substrate formed of a hard alloy selected from the group consisting of a WC-based cemented carbide and a TiCN-based cermet, and a hard coating deposited on said substrate, the hard coating including an inner layer of TiCN having unilaterally grown crystals of an elongated shape and an outer layer of Al_2O_3 having a crystal form κ or κ + α wherein κ > α .

[0015] In order to practicalize the present invention, it is first necessary to coat the substrate with elongated crystal TiCN having high bonding strength. If the conditions are such that, for example, during the coating of the TiCN, the percentages of the respective volumes are: TiCl4: 1-10%, CH₃CN: 0.1-5%, N₂: 0-35%, H₂: the rest, the reaction temperature is 800-950 °C, the pressure is 30-500 Torr, and furthermore, the CH₃CN gas is decreased to 0.01-0.1% at the beginning of the coating as a first coating reaction for 1-120 minutes, then the CH₃CN gas is increased to 0.1-1% as a second coating reaction, then elongated crystal TiCN having high bonding strength can be obtained. The thickness of the TiCN coating layer should preferably be 1-20 μm. This is because at less than 1 μm the wear resistance worsens, and at more than 20 μm the fracture resistance worsens.

[0016] Furthermore, during the coating of the TiCN, if the reaction temperature or the amount of CH₃CN is increased, the (200) plane component of the X-ray diffraction pattern of the TiCN becomes weaker than the (111) and (220) plane components, the bonding strength with the Al_2O_3 in the upper layer which has κ as its main form increases, and the wear resistance goes up.

[0017] Next, Al_2O_3 of κ form or κ + α form wherein form κ > α is coated. For coating Al_2O_3 which has κ as its principal form, the conditions should be such that, for example, the reaction gas is made up of the following volume percentages in the first 1-120 minutes: $AlCl_3$: 1-20%, HCl: 1-20% and/or H_2S : 0.05-5% as needed, and H_2 : the rest, and a first reaction be performed, then afterwards, a second reaction is performed in which $AlCl_3$: 1-20%, CO_2 : 0.5-30%, HCl: 1-20% and/or H_2S : 0.05-5% as needed, and H_2 : the rest, with the conditions of a reaction temperature of 850-1000 °C and pressure of 30-500 Torr.

[0018] The thickness of this Al_2O_3 coating layer should preferably be 0.1-10 μ m. At less than 0.1 μ m the wear resistance worsens, while at over 10 μ m the fracturing resistance worsens.

[0019] The combined thickness of the first TiCN layer and the second Al₂O₃ layer should preferably be 2-30 µm.

[0020] The K ratio of the $\kappa + \alpha$ Al₂O₃ of the present invention uses a peak from Cu- $\kappa\alpha$ X-ray diffraction, and is determined the following equation, wherein if $\kappa > \alpha$ then the κ ratio is over 50%.

$$I_{\kappa 2.79} + I_{\kappa 1.43}$$

 κ ratio (%) = ----- × 100
 $I_{\kappa 2.79} + I_{\kappa 1.43} + I_{\alpha 2.085} + I_{\alpha 1.601}$

50 wherein

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 $I_{\kappa2.79}$: The height of the X-ray diffraction peak for ASTM No. 4-0878 with a plane index spacing of d = 2.79 The height of the X-ray diffraction peak for ASTM No. 4-0878 with a plane index spacing of d = 1.43 The height of the X-ray diffraction peak for ASTM No. 10-173 with a plane index spacing of d = 2.085 (the (113) plane) $I_{\alpha1.601}$: The height of the X-ray diffraction peak for ASTM No. 10-173 with a plane index spacing of d = 1.601 (the (116) plane)

[0021] As further modified embodiments of the present invention, the following are included.

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- (1) As an outermost layer, either one or both of TiN or TiCN may be coated on the outer Al_2O_3 layer. The reason for this coating layer is to discriminate between areas of use, and a thickness of 0.1-2 μ m is preferable.
- (2) As an innermost layer, either one or more of TiN, TiC, or TiCN (granular form) may be coated underneath the inner TiCN layer. By coating with this innermost layer, the bonding strength of the elongated crystal TiCN improves and the wear resistance improves. The most preferable thickness for this coating is 0.1-5 µm.
- (3) Between the inner TiCN layer and the outer Al₂O₃ layer, either one or more of TiN, TiC, or TiCN (granular form) may be coated as a first intermediate layer. This first intermediate layer improves the wear resistance during low speed cutting. However, during high speed cutting, it worsens the wear resistance. The most preferable thickness for this first intermediate layer is 1-7 µm.
- (4) Between the inner TiCN layer and the outer Al_2O_3 layer, either one or both of TiCO, TiCNO is coated as a second intermediate layer. This second intermediate layer increases the bonding strength between the elongated crystal TiCN and the κ or κ + α form Al_2O_3 . The most preferable thickness of this second intermediate layer is 0.1-2 μ m. (5) It is possible to combine the above-mentioned (1)-(4) as appropriate.
- (6) The inner layer coated with elongated crystal TiCN may be divided by one or more TiN layers to define a divided TiCN layer. This divided TiCN layer is less susceptible to chipping, and the fracture resistance improves.
- (7) With the divided elongated TiCN described above and the κ or κ + α form Al $_2$ O $_3$, it is possible to coat with an outermost layer of one or both of TiN or TiCN as in (1) above, coat with an innermost layer of one or more of TiN, TiC, or TiCN as in (2) above, coat with a first intermediate layer of one or more of TiC, TiN, or TiCN as in (3) above, coat with a second intermediate layer of one or both of TiCO or TiCNO as in (4) above, or to take a combination of them
- (8) The most preferable composition of the WC-based cemented carbide substrate is, by the percentage of weight, as follows:

| Co: 4-12% | Ti: 0-7% | Ta: 0-7% |
|-----------|-------------------|----------|
| Nb: 0-4% | Cr: 0-2% | • |
| N: 0-1% | W and C: the rest | |

Unavoidable impurities such as O, Fe, Ni, and Mo are also included.

(9) For the WC-based cemented carbide of the present invention, for lathe turning of steel, it is preferable that the cemented carbide be such that the amount of Co or Co + Cr in the surface portion (the highest value from the surface to within 100 μ m) be 1.5 to 5 times the amount in the interior (1 mm from the surface), and for lathe turning of cast iron, it is preferable that there is no enrichment of the Co or Co + Cr, and that the amount of Co or Co + Cr be small. Furthermore, in the case of steel milling, cemented carbide in which there has been no enrichment of the Co or Co + Cr, and the amount of Co or Co + Cr is large, is preferable.

(10) The most preferable composition of the TiCN-based cermet substrate is, by the percentage of weight, as follows:

| Co: 2-14% | Ni: 2-12% | Ta: 2-20% |
|---------------------|--------------------|-----------|
| Nb: 0.1-10% | W: 5-30% | Mo: 5-20% |
| N: 2-8% | Ti and C: the rest | |
| Cr, V, Zr, Hf: 0-5% | | |

Unavoidable impurities such as O and Fe are included.

(11) In the TiCN-based cermet of the present invention, the substrate surface layer (the largest value within 100 μ m of the surface) should be 5% or more harder than the interior (1 mm from the surface) or there should be no difference between the hardnesses of the surface layer and the interior.

[0022] The present invention will be explained in more detail by way of the following examples.

EXAMPLE 1

[0023] As the raw materials, medium grain WC powder having an average particle size of 3 μ m, 5 μ m coarse grain WC powder, 1.5 μ m (Ti, W)C (by weight ratio, TiC/WC = 30/70) powder 1.2 μ m (Ti, W)(C, N) (TiC/TiN/WC = 24/20/56) powder, 1.5 μ m Ti(C, N) (TiC/TiN = 50/50) powder, 1.6 μ m (Ta, Nb)C (TaC/NbC=90/10) powder, 1.8 μ m TaC powder, 1.1 μ m Mo₂C powder, 1.7 μ m ZrC powder, 1.8 μ m Cr₃C₂ powder, 2.0 μ m Ni powder, 2.2 μ m NiAl (Al: 31% by weight) powder, and 1.2 μ m Co powder were prepared, then these raw material powders were blended in the compositions shown in Table 1 and wet-mixed in a ball mill for 72 hours. After drying, they were press-shaped into green compacts of the form of ISO CNMG 120408 (cemented carbide substrates A-D, cermet substrates F-G) and SEEN 42 AFTN 1 (cemented carbide substrates E and E'), then these green compacts were sintered under the conditions described in Table 1, thus resulting in the production of cemented carbide substrates A-E, E' and cermet substrates F-G.

[0024] Experimental values taken at over 1 mm from the surface of the sintered compacts of the cemented carbide substrates A-E, E' and the cermet substrates F-G are as shown in Table 2.

[0025] Furthermore, in the case of the above cemented carbide substrate B, after maintenance in an atmosphere of CH₄ gas at 100 torr and a temperature of 1400 °C for 1 hour, a gradually cooling carburizing procedure was run, then, by removing the carbon and Co attached to the substrate surface using acid and barrel polishing, a Co-rich region 40 µm deep was formed in the substrate surface layer wherein, at a position 10 µm from the surface the maximum Co content was 15% by weight.

[0026] Additionally, in the case of cemented carbide substrates A and D above, while sintered, a Co-rich region 20 μm deep was formed wherein, at a position 15 μm from the surface, the maximum Co content was 11% and 9% by weight, respectively, and in the remaining cemented carbide substrates C, E and E', no Co-rich region was formed, and they had similar compositions over their entirety.

[0027] In the above cermet substrates F and G, in the sintered state, a surface layer harder than the interior existed. The hardnesses at the surface and 1 mm below the surface for the cermet substrates F and G are shown in Table 2.

[0028] Next, after honing the surfaces of the cemented carbide substrates A-E, E' and cermet substrates F and G, by forming coating layers under the special coating conditions shown in Tables 3(a) and 3(b) and having the compositions, crystal structures, orientation of TiCN (shown, starting from the left, in the order of the intensity of the corresponding X-ray diffraction peak) and average thicknesses shown in Table 4 by using a chemical vapor deposition apparatus, the coated cemented carbide cutting tools of the present invention 1-12 and 15-26, the coated cermet cutting tools of the present invention 13, 14, 27, and 28, the coated cemented carbide cutting tools of the prior art 1-12 and 15-26, and the coated cermet cutting tools 13, 14, 27, and 28 of the prior art were produced.

[0029] Then, for the coated cemented carbide cutting tools of the present invention 1-10 and 15-24, and the coated cemented carbide cutting tools of the prior art 1-10 and 15-24, a mild steel continuous cutting test was performed under the following conditions,

Workpiece: mild steel round bar Cutting Speed: 270 m/min Feed: 0.25 mm/rev Depth of Cut: 2 mm Cutting Time: 30 min

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in which a determination was made whether or not the cutting failed due to tears made in the workpiece because of chipping of the cutting blade or spalling of the coating layer. Then, for those which were able to cut for the set period of time, the amount of flank wear was measured. Furthermore, an interrupted cutting test was performed under the following conditions,

Workpiece: mild steel round bar with groove Cutting Speed: 250 m/min Feed: 0.25 mm/rev Depth of Cut: 1.5 mm Cutting Time: 40 min

in which a determination was made whether or not the cutting failed due to trouble such as fracturing or chipping of the cutting blade. Then, for those which were able to cut for the set period of time, the amount of flank wear was measured. [0030] For the coated cemented carbide cutting tools of the present invention 11, 12, 25 and 26, and the coated cemented carbide cutting tools of the prior art 11, 12, 25 and 26, a mild steel milling test was performed under the following conditions,

Workpiece: mild steel square block;

Cutting Speed: 250 m/min Feed: 0.35 mm/tooth Depth of Cut: 2.5 mm Cutting Time: 40 min

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in which a determination was made whether or not the milling failed due to trouble such as chipping of the cutting blade. Then, for those which were able to cut for the set period of time, the amount of flank wear was measured.

[0031] For the coated cermet cutting tools of the present invention 13, 14, 27 and 28, and the coated cermet cutting tools of the prior art 13, 14, 27 and 28, a mild steel continuous cutting test was performed under the following conditions,

Workpiece: mild steel round bar Cutting Speed: 320 m/min Feed: 0.25 mm/rev Depth of Cut: 1 mm

Cutting Time: 20 min

in which a determination was made whether or not the cutting failed due to chipping or fracturing of the cutting blade.

Then, for those which were able to cut for the set period of time, the amount of flank wear was measured. Furthermore,

an interrupted cutting test was performed under the following conditions,

Workpiece: mild steel round bar with groove

Cutting Speed: 300 m/min Feed: 0.20 mm/rev Depth of Cut: 1 mm Cutting Time: 20 min

in which a determination was made whether or not the cutting failed due to trouble such as chipping of the cutting blade. Then, for those which were able to cut for the set period of time, the amount of flank wear was measured.

[0032] The results of the above tests are shown in Tables 4-7. As is able to be seen from Tables 4-7, all of the coated cemented carbide cutting tools and coated cermet cutting tools of the present invention demonstrate the properties that it is difficult to fracture or chip the cutting blades and spalling of the coating layers is rare, in addition to exhibiting superior wear and fracture resistance.

35 EXAMPLE 2

[0033] Using the same cemented carbide substrates A-E, E' and cermet substrates F and G as Example 1, under the same coating conditions as shown in Tables 3(a) and 3(b) in Example 1, by forming coating layers of the composition, crystal structures, and average thicknesses shown in Tables 8 and 9, the coated cemented carbide cutting tools of the present invention 29-40, the coated cermet cutting tools of the present invention 41 and 42, the coated cemented carbide cutting tools of the prior art 29-40. and the coated cermet cutting tools 41 and 42 of the prior art were produced.

[0034] Then, for the coated cemented carbide cutting tools of the present invention 29-38, and the coated cemented carbide cutting tools of the prior art 29-38, a mild steel continuous cutting test was performed under the following conditions,

Workpiece: mild steel round bar Cutting Speed: 250 m/min Feed: 0.27 mm/rev Depth of Cut: 2 mm Cutting Time: 30 min

and an appraisal identical to that of Example 1 was made. Furthermore, an interrupted cutting test was performed under the following conditions,

Workpiece: mild steel round bar with groove

Cutting Speed: 230 m/min Feed: 0.27 mm/rev Depth of Cut: 1.5 mm

Cutting Time: 40 min

and an appraisal identical to that of Example 1 was made.

[0035] For the coated cemented carbide cutting tools of the present invention 39 and 40, and the coated cemented carbide cutting tools of the prior art 39 and 40, a mild steel milling test was performed under the following conditions,

Workpiece: mild steel square block

Cutting Speed: 230 m/min Feed: 0.37 mm/tooth Depth of Cut: 2.5 mm Cutting Time: 40 min

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and an appraisal identical to that of Example 1 was made.

[0036] For the coated cermet cutting tools of the present invention 41 and 42, and the coated cermet cutting tools of the prior art 41 and 42, a mild steel continuous cutting test was performed under the following conditions,

Workpiece: mild steel round bar Cutting Speed: 300 m/min Feed: 0.27 mm/rev Depth of Cut: 1 mm Cutting Time: 20 min

and an appraisal identical to that of Example 1 was made. Furthermore, an interrupted cutting test was performed under the following conditions,

Workpiece: mild steel round bar with groove

Cutting Speed: 280 m/min Feed: 0.22 mm/rev Depth of Cut: 1 mm Cutting Time: 20 min

and an appraisal identical to that of Example 1 was made.

[0037] The results of the above tests are shown in Tables 8, 9(a) and 9(b). As is able to be seen from Tables 8, 9(a) and 9(b), all of the coated cemented carbide cutting tools and coated cermet cutting tools of the present invention demonstrate the properties that it is difficult to fracture or chip the cutting blades and spalling of the coating layers is rare, in addition to exhibiting superior wear and fracture resistance.

EXAMPLE 3

[0038] Using the same cemented carbide substrates A-E, E' and cermet substrates F and G as Example 1, under the same coating conditions as shown in Tables 3(a) and 3(b) in Example 1, by forming coating layers of the composition, crystal structures, and average thickness shown in Tables 10-13, the coated cemented carbide cutting tools of the present invention 43-54 and 57-68, the coated cermet cutting tools of the present invention 55,56, 69 and 70, the coated cemented carbide cutting tools of the prior art 43-54 and 57-68, and the coated cermet cutting tools 55, 56, 69 and 70 of the prior art were produced. Figure 1 shows a photograph of the surface layer of the coated cemented carbide cutting tool of the present invention as taken by a scanning electron microscope.

[0039] Then, for the coated cemented carbide cutting tools of the present invention 43-52 and 57-66, and the coated cemented carbide cutting tools of the prior art 43-52 and 57-66, a mild steel continuous cutting test was performed under the following conditions.

Workpiece: mild steel round bar Cutting Speed: 280 m/min Feed: 0.23 mm/rev Depth of Cut: 2 mm

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and an appraisal identical to that of Example 1 was made. Furthermore, an interrupted cutting test was performed under the following conditions,

Workpiece: mild steel round bar with groove

Cutting Speed: 260 m/min Feed: 0.23 mm/rev Depth of Cut: 1.5 mm Cutting Time: 40 min

and an appraisal identical to that of Example 1 was made.

[0040] For the coated cemented carbide cutting tools of the present invention 53, 54, 67 and 68, and the coated cemented carbide cutting tools of the prior art 53, 54, 67 and 68, a mild steel milling test was performed under the following conditions,

Workpiece: mild steel square block

Cutting Speed: 260 m/min Feed: 0.33 mm/tooth Depth of Cut: 2.5 mm Cutting Time: 40 min

and an appraisal identical to that of Example 1 was made.

[0041] For the coated cermet cutting tools of the present invention 55, 56, 69 and 70, and the coated cermet cutting tools of the prior art 55, 56, 69 and 70, a mild steel continuous cutting test was performed under the following conditions,

Workpiece: mild steel round bar Cutting Speed: 330 m/min Feed: 0.23 mm/rev Depth of Cut: 1 mm

Cutting Time: 20 min

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and an appraisal identical to that of Example 1 was made. Furthermore, an interrupted cutting test was performed under the following conditions,

Workpiece: mild steel round bar with groove

Cutting Speed: 310 m/min Feed: 0.18 mm/rev Depth of Cut: 1 mm Cutting Time: 20 min

and an appraisal identical to that of Example 1 was made.

[0042] The results of the above tests are shown in Tables 10-13. As is able to be seen from Tables 10-13, all of the coated cemented carbide cutting tools and coated cermet cutting tools of the present invention demonstrate the properties that it is difficult to fracture or chip the cutting blades and spalling of the coating layers is rare, in addition to exhibiting superior wear and fracture resistance.

EXAMPLE 4

[0043] Using the same cemented carbide substrates A-E, E' and cermet substrates F and G as Example 1, under the same coating conditions as shown in Tables 3(a) and 3(b) in Example 1, by forming coating layers of the composition, crystal structures, and average thicknesses shown in Tables 14-17, the coated cemented carbide cutting tools of the present invention 71-82 and 85-96, the coated cermet cutting tools of the present invention 83, 84, 97 and 98, the coated cemented carbide cutting tools of the prior art 71-82 and 85-96, and the coated cermet cutting tools 83, 84, 97 and 98 of the prior art were produced.

[0044] Then, for the coated cemented carbide cutting tools of the present invention 71-80 and 85-94, and the coated cemented carbide cutting tools of the prior art 71-80 and 85-94, a mild steel continuous cutting test was performed under the following conditions,

Workpiece: mild steel round bar Cutting Speed: 260 m/min Feed: 0.26 mm/rev Depth of Cut: 2 mm

Cutting Time: 30 min

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and an appraisal identical to that of Example 1 was made. Furthermore, an interrupted cutting test was performed under the following conditions,

Workpiece: mild steel round bar with groove

Cutting Speed: 240 m/min Feed: 0.26 mm/rev Depth of Cut: 1.5 mm Cutting Time: 40 min

and an appraisal identical to that of Example 1 was made.

[0045] For the coated cemented carbide cutting tools of the present invention 81, 82, 95 and 96, and the coated cemented carbide cutting tools of the prior art 81, 82, 95 and 96, a mild steel milling test was performed under the following conditions,

Workpiece: mild steel square block

Cutting Speed: 240 m/min Feed: 0.36 mm/tooth Depth of Cut: 2.5 mm Cutting Time: 40 min

and an appraisal identical to that of Example 1 was made.

[0046] For the coated cermet cutting tools of the present invention 83, 84, 97 and 98, and the coated cermet cutting tools of the prior art 83, 84, 97 and 98, a mild steel continuous cutting test was performed under the following conditions,

Workpiece: mild steel round bar Cutting Speed: 310 m/min Feed: 0.26 mm/rev Depth of Cut: 1 mm Cutting Time: 20 min

and an appraisal identical to that of Example 1 was made. Furthermore, an interrupted cutting test was performed under the following conditions,

Workpiece: mild steel round bar with groove

Cutting Speed: 290 m/min Feed: 0.21 mm/rev Depth of Cut: 1 mm Cutting Time: 20 min

and an appraisal identical to that of Example 1 was made.

[0047] The results of the above tests are shown in Tables 14-17. As is able to be seen from Tables 14-17, all of the coated cemented carbide cutting tools and coated cermet cutting tools of the present invention demonstrate the properties that it is difficult to fracture or chip the cutting blades and spalling of the coating layers is rare, in addition to exhibiting superior wear and fracture resistance.

EXAMPLE 5

[0048] Using the same cemented carbide substrates A-E, E' and cermet substrates F and G as Example 1, under the same coating conditions as shown in Tables 3(a) and 3(b) in Example 1, by forming coating layers of the composition, crystal structures, and average thicknesses shown in Tables 18-21, the coated cemented carbide cutting tools of the present invention 99-112 and 122-126, the coated cermet cutting tools of the present invention 113-121, the coated cemented carbide cutting tools of the prior art 99-112 and 122-126, and the coated cermet cutting tools 113-121 of the prior art were produced.

[0049] Then, for the coated cemented carbide cutting tools of the present invention 99-112, and the coated cemented carbide cutting tools of the prior art 99-112, a mild steel high-feed continuous cutting test was performed under the following conditions,

Workpiece: mild steel round bar Cutting Speed: 210 m/min Feed: 0.38 mm/rev

Depth of Cut: 2 mm 5 Cutting Time: 30 min

and an appraisal identical to that of Example 1 was made. Furthermore, a deep cut interrupted cutting test was performed under the following conditions,

10 Workpiece: mild steel round bar

Cutting Speed: 210 m/min Feed: 0.23 mm/rev Depth of Cut: 4 mm Cutting Time: 40 min

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and an appraisal identical to that of Example 1 was made.

[0050] For the coated cemented carbide cutting tools of the present invention 122-126, and the coated cemented carbide cutting tools of the prior art 122-126, a mild steel milling test was performed under the following conditions,

20 Workpiece: mild steel square block

Cutting Speed: 260 m/min Feed: 0.33 mm/tooth Depth of Cut: 3 mm Cutting Time: 40 min

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and an appraisal identical to that of Example 1 was made.

[0051] For the coated cermet cutting tools of the present invention 113-121, and the coated cermet cutting tools of the prior art 113-121, a mild steel continuous cutting test was performed under the following conditions,

30 Workpiece: mild steel round bar

Cutting Speed: 340 m/min Feed: 0.22 mm/rev Depth of Cut: 1 mm Cutting Time: 20 min

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and an appraisal identical to that of Example 1 was made. Furthermore, an interrupted cutting test was performed under the following conditions,

Workpiece: mild steel round bar with groove

Cutting Speed: 320 m/min

Feed: 0.17 mm/rev Depth of Cut: 1 mm Cutting Time: 20 min

and an appraisal identical to that of Example 1 was made.

[0052] The results of the above tests are shown in Tables 18-21. As is able to be seen from Tables 18-21, all of the coated cemented carbide cutting tools and coated cermet cutting tools of the present invention demonstrate the properties that it is difficult to fracture or chip the cutting blades and spalling of the coating layers is rare, in addition to exhibiting superior wear and fracture resistance.

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TABLE 1

| Туре | | | | Blend Compos | Blend Composition (% by weight) | veight) | | Sin | Sintering Conditions | ons. |
|----------------------------------|----------|----------|---------------------------|---------------|---|-----------|---------------------------|-----------------------|----------------------|------------------------|
| | | ပိ | (Ti, W)C | (Ti, W)CN | (Ta, Nb)C | Cx3C2 | JM. | Pressure | Temperature (°C) | Holding Time(hours) |
| · | < | 9 | , | 9 | 4 | 1 | Balanco (medium grain) | Vacuum (0.10 torr) | 1380 | 7 |
| I, | E | r | \$ | • | \$. | 1 | Balance (medium grain) | Vacuum (0.05 torr) | 1450 | 1 |
| Cemented Carbide Substrate | υ | ٥ | æ | , | 5 | | Balance (médium grain) | Vacuum (0.05 torr) | 1380 | 1.5 |
| | ٥ | ۶ | | \$. | 3 | , | Balance (medium grain) | Vacuum (0.05 torr) | 1410 | 1 |
| : | ы | . 10 | | • | 2 | , | Balance (coarse grain) | Vacuum (0.05 torr) | 1380 | |
| | 'n | 10 | · | - | - | 7.0 | Balance (coarse grain) | Vacuum (0.05 torr) | 1380 | 1 |
| Cermen | Ĺ. | 30.2 Tic | iC - 23 TiN - 0.3 NiAl | 10 TaC - 13 t | TiC - 23 TiN - 10 TaC - 13 WC - 10 Mo ₂ C - 0.5 ZrC - 8 Co - | - 0.5 ZrC | 8 Co - | Vacuum (0.10 torr) | 1500 | 1.5 |
| Substrate | U | 57 TICN | - 10 TaC - 1 | NDC - 9 WC | 57 TiCN - 10 TaC - 1 NbC - 9 WC - 9 Mo2C - 7 Co - 7 Ni | Co - 7 NJ | | N2 Atmosphere | 1520 | 1.5 |

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TABLE 2

| | | continue of cinerad Body (4 by weight) | Hard | Hardness |
|-----------|--------|--|-------------------|------------------|
| | | יייייייייייייייייייייייייייייייייייייי | Interior (HRA) | Surface (HRA) |
| | 4 | 6.1 Co - 2.1 Ti - 3.4 Ta - 0.4 Nb - Rest (W + C) | 90.5 | • |
| | E | 5.2 Co - 1.2 Ti - 4.2 Ta - 0.4 Nb - Rest (W + C) | 91.0 | 4 |
| <u> </u> | U | 9.0 Co - 1.9 Ti - 4.3 Ta - 0.4 Nb - Rest (W + C) | 90.3 | 1 |
| Cemented | ۵ | 5.2 Co - 1.7 Ti - 2.5 Ta - 0.3 Nb - Rest (W + C) | 91.1 | 1 |
| Substrate | ш | 9.8 Co - 1.7 Ta - 0.2 Nb - Rest (W + C) | 69.7 | • |
| | : : | 9.8 Co - 0.6 Cr - Rest (W + C) | 83.8 | , |
| | (ia | 9.4 Ta - 12.2 W - 9.4 HO - 0.4 Zr - 7.9 Co - 5.1 Ni - 0.1 Al - 3.8 N - | 91.7 | 92.2 |
| Substrate | U | 9,5 Ta - 0.9 Nb - 8,5 W - 8,5 Mo - 7,1 Co - 7.0 Ni - 6.8 N - Rest (Ti + C) | 91.6 | 92.6 |

TABLE 3 (a)

[Coating Conditions]

| _ | (coating cond. | | | | |
|-----------|--|----------------------|---|------------------|--------------------|
| 5 | Composition | X-ray Orientation | Gas Composition (% by volume) | Temperature (°C) | Pressure (Torr) |
| 10 | Innermost Layer Granular TiC | | TiCl ₄ :2, CH ₄ :5, H ₂ :Rest | 1020 | 50 |
| | Innermost Layer Granular TiN | | TiCl4:2, N2:25, H2:Rest | 920 | 50 |
| 15 | Innermost Layer Granular TiCN | | TiCl ₄ :2, CH ₄ :4, N ₂ :20, H ₂ :Rest | 1020 | 50 |
| 73 | Inner Layer Elongated TiCN | (1111 (220) (200) | First Reaction - TiCl ₄ :2, CH ₃ CN:0.05, N ₂ :20, H ₂ :Rest Second Reaction - TiCl ₄ :2, CH ₃ CN:0.6, N ₂ :20, H ₂ :Rest | 860 | 50 |
| 20 | Inner Layer Elongated TiCN | (220) (111) (200) | First Reaction - TiCl ₄ :2. CH ₃ CN:0.05, N ₂ :20. H ₂ :Rest Second Reaction - TiCl ₄ :2, CH ₃ CN:0.6, N ₂ :20, H ₂ :Rest | 900 | 50 |
| | Inner Layer Elongated TiCN | (111) (200) (220) | First Reaction - TiCl ₄ :2, CH ₃ CN:0.05, N ₂ :20, H ₂ :Rest Second Reaction - TiCl ₄ :2, CH ₃ CN:0.3, N ₂ :20, H ₂ :Rest | 860 | 50 |
| 25 | Inner Layer Elongated TiCN | (220) (200) (111) | First Reaction - TiCl ₄ :4, CH ₃ CN:0.05, N ₂ :20, H ₂ :Rest Second Reaction - TiCl ₄ :4, CH ₃ CN:0.3, N ₂ :20, H ₂ :Rest | 900 | 50 |
| 30 | Inner Layer Granular TiCN | (111) (200) (220) | TiCl4:4, CH4:6, N2:2, H2:Rest | 1050 | 500 |
| | Inner Layer Granular TiCN | (220) (200) (111) | TiCl4:4, CH4:4, N2:2, H2:Rest | 1050 | 500 |
| • | Inner Layer Granular TiCN | (200) (220) (111) | TiCl4:4, CH4:2, N2:2, H2:Rest | 1000 | 100 |
| 35 | Divided Layer Granular TiN | | TiCl ₄ :2. N ₂ :25. H ₂ :Rest | 900 | 200 |
| | Divided Layer Granular TiN | | TiCl4:2, N2:25, H2:Rest | 860 | 300 |
| 40 | First Incermediate Layer | | TiCl4:2. CH4:5. H2:Rest | . 1020 | 50 |
| 45 | Granular TiC First Intermediate Layer Granular TiCN | | TiCl4:2. CH4:4. N2:20. H2:Resc | 1020 | 50 |
| | Second Intermediate Layer Granular TiCO | | TiCl ₄ :4. CO:6. H ₂ :Rest | 980 | 50 |
| 50 | Second Intermediate Layer Granular TiCNO | | TiCl ₄ :4. CH ₄ :2, N2:1.5, CO ₂ :0.5, H ₂ :Rest | 1000 | 50 |

TABLE 3 (b)

| 5 | | | <u></u> | 1 | |
|----|---|----------------------|--|------------------|--------------------|
| | Composition | X-ray Orientation | Gas Composition (% capacity) | Temperature (°C) | Pressure (Torr) |
| 10 | Outer Layer Al ₂ O ₃ | 100 % K | First Reaction - AlCl ₃ :3%. H ₂ :Rest Second Reaction - AlCl ₃ :3%. CO ₂ :5%. H ₂ S:0.3. H ₂ :Rest | 970 | 50 |
| | Outer Layer Al ₂ O ₃ | 94%K | First Reaction - AlCl3:3%, H2:Rest Second Reaction - AlCl3:3%, CO2:5%, H2:Rest | 970 | 50 |
| 15 | Outer Layer Al ₂ O ₃ | 858× | First Reaction - AlCl3:3%, H2:Rest Second Reaction - AlCl3:3%, CO2:6%, H2S:0.2, H2:Rest | 980 | 50 |
| * | Outer Layer Al ₂ O ₃ | 73 % K | First Reaction - AlCl ₃ :3%, H ₂ :Rest Second Reaction - AlCl ₃ :3%, CO ₂ :6%, H ₂ :Rest | 980 | 50 |
| 20 | Outer Layer Al ₂ O ₃ | 62%K | First Reaction - AlCl ₃ :3%, H ₂ :Rest Second Reaction - AlCl ₃ :3%, CO ₂ :7%, H ₂ S:0.2, H ₂ :Rest | 990 | . 50 |
| | Outer Layer Al ₂ O ₃ | 55%K | First Reaction - AlCl3:3%, H2:Rest Second Reaction - AlCl3:3%, CO2:8%, H2:Rest | 1000 | 50 |
| 25 | Outer Layer Al ₂ O ₃ | 408K | First Reaction - AlCl ₃ :3%, H ₂ S:0.05, H ₂ :Rest Second Reaction - AlCl ₃ :3%, CO ₂ :9%, H ₂ S:0.1, H ₂ :Rest | 1010 | 50 |
| | Outer Layer | 100\$α | AlCl ₃ :3%, CO ₂ :10%, H ₂ :Rest | 1020 | 100 |
| 30 | Outermost Layer Granular TiN | | TiCl4:2, N2:30, H2:Rest | 1020 | 200 |
| | Outermost Layer Granular TiN | | TiCl4:2. CH4:4. N2:20. H2:Rest | 1020 | 200 |

TABLE 4

| | - | | | | Hard C | Hard Coating Layer | | | | Flank Wear | Wear |
|-------------|----|-----------|-------------|-------------|--------------------|--------------------|---------|-----------------|----------------------|-----------------------|------------------------|
| Туре | | Substrate | | Inner Layer | J.(| Outer Layer | ayer | Outermost Layer | . Layer | (uau) | n) |
| | | Symbol | Composition | Crystal | Orientation | Composition | Crystal | Composition | Crystal Structure | Continuous Cutting | Interrupted Cutting |
| | E | d | TiCN(8.4) | Elongated | (111) (220) (200) | A1203 (2.2) | x:948 | TIN(0.5) | Granular | 61.0 | 0.26 |
| | 2 | < | TiCN(5.5) | Elongated | (220) (111) (200) | A1203(6.2) | X:851 | | | 0.19 | 0.28 |
| | ٦ | 4 | TiCN(11.4) | Growth | (111) (220) (200) | A1203(1.8) | K: 1004 | TiCN- | Granular | 0.19 | 0.31 |
| - | ~ | B | TiCN(8.2) | Elongated | (111) (200) (220) | A1203(2.1) | K: 1008 | TIN10.4) | Granulor | 0.17 | 0.31 |
| Coated | 5 | а | TICN (5.1) | Elongated | (111) (220) (200) | A1203 (5.2) | K: 738 | | | 0.21 | 0.26 |
| Cementing | 9 | U | TiCM(10.2) | Elongated | (220) (111) (200) | A1203(1.2) | K: 558 | Tin(0.3) | Granular | 0.22 | 0.31 |
| Carbide | - | ٥ | TICN(5.4) | Elongarcd | (220) (200) (111) | ١١٥٥٥ (١٥.9) | K: 628 | TIN(0.6) | Granular | 0.26 | 0.34 |
| Cutting | ۰ | Q | TiCN(6.4) | Elongated | (111) (220) (200) | A1203(5.7) | X:738 | TiN(0.2) | Granular | 0.16 | 0.26 |
| Tool | 6 | G | Tich(3.7) | Elongated | (220) (111) (200) | A1203(8.2) | K: 62% | | | 0.17 | 0.30 |
| of the | 10 | Q | TiCN(7.9) | Elongated | (111) (220) (200) | A1203 (2.5) | K: 1001 | | | 0.18 | 0.26 |
| Invention | = | æ | TiCN(4.2) | Elongated | (220) (111) (200) | A1203(0.5) | K: 1008 | | | 0.17 | (Hilling) |
| | 12 | w | TiCN(4.0) | Elongated | (111) (220) (200) | A1203(0.4) | K: 944 | TiN(0.3) | Granular | 0.19 | (Milling) |
| | = | <u> </u> | TiCN(4.6) | Elongated | (220) (1111) (220) | A1203(0.4) | K: 1001 | TiN(0.4) | Granular | 0.16 | 0.29 |
| | = | U | TiCN(3.2) | Elongated | (111) (220) (200) | A120310.8) | K:941 | TiN(0.2) | Granular | 0.16 | 0.2, |

TABLE 5

| | | | | | Hard C | Hard Coating Layer | | | | Flank Wear | Wear |
|----------------------------------|------|-----------|-------------|-------------|--------------------|--------------------|----------|-------------------|----------------------|--|---|
| Туре | | Substrate | | Inner Layer | 3,5 | Outer Layer | 'pher | Outermost Layer | Layer | (mau) | u) |
| | | Symbol | Composition | Crystal | Orientation | Composition | Crystal | Composition | Crystal Structure | Continuous | Interrupted Cutting |
| | - | < | TiCN(8.5) | Granular | (111) (200) (220) | A1203(2.0) | α:1001 | T1N(0.5) | Granular | 0.47 (Chipping) | 0.60 (Chipping) |
| | 2 | < | TiCN(5.4) | Granular | (220) (200) (111) | A1203(6.0) | a: 100% | * | | 0.52 (Chipping) | 0.56 (Chipping) |
| | _ | 4 | TiCN(11.3) | Granular | (111) (200) (220) | A1203 (1.9) | K:404 | TiCN- TiN(0.8) | Granular | 0.52 (Chipping) | 0.65 (Chipping) |
| | 4 | 60 | TiCN(8.1) | Granular | (200) (220) (111) | A1203 (2.2) | α: 1008 | TIN(0.3) | Granular | Pailure after 12.8 min. due to Layer Separation | Fallure after 7.5 min. due to Layer Separation |
| | 'n | 8 | TiCN(4.9) | Granular | (111) (200) (220) | A1203 (5.2) | α: 100\$ | | | Failure after 10.7 min. due to Layer Separation | Feilure after 5.3 min. due to Layer Separation |
| Coated Cemented | ۰ . | U | TiCN(10.3) | Granular | (220) (200) (111) | A1203(1.1) | α: 1004 | TIN(0.4) | Granular | Failure after 5.6 min. due to Layer Separation | Failure after 0.8 min. due to Fracturing |
| Cutting Tools of Prior Art | _ | U | TiCN(5.5) | Granular | (200) (220) (1111) | A1203(1.11 | K:408 | TiN(0.5) | Granular | Pailure after 10.4 min. due to Layer Separation | Failure after 3.2 min. due to Fracturing |
| | 60 | G | TiCN(6.5) | Granular | (111) (200) (220) | A1203 (5.6) | α:1004 | TiN(0.3) | Granular | Pailure after 17.1 min. due to Chipping | Failure aiter 7.9 min. due to Chipping |
| | 5 | ٥ | ricn().8) | Gramular | (220) (200) (111) | A1203(8.4) | K:408 | | | Failure after 15.4 min. due to Chipping | Failure after 5.2 min. due to Chipping |
| | . 0. | a | Tick(7,7) | Granular | (111) (200) (220) | 11203 (2.4) | a: 1001 | | | Failure after 13.6 min. due to Chipping | Failure after 7.0 min. due co Chipping |
| | = | 13 | TiCN(4.1) | Granular | (220) (200) (111) | A1203 (0.6) | α:1000 | | | Failure after 20.8 min. due ro Chipping (Milling) | .8 min. due ro |
| | 12 | is | TiCN(3.9) | Granular | (111) (200) (220) | A1203 (0.3) | α:1001 | TiN(0.2) | Granular | Pailure after 17.7 min. due to Layer Separation (Milling) | (Milling) |
| | = | L | TiCN(4.4) | Granular | (220) (200) (111) | A1203 (0.4) | α:100N | TiN(0.4) | Granular | Failure after 1.0 min. due to Chipping | Failure after 0.1 min. due to Fracturing |
| | 77 | O | T1CH(3.3) | Granular | (111) (200) (220) | A1203 (0.9) | a: 1001 | Tin10.3) | Granular | Failure after 2.8 min. due to Chippins | Failure after 0.2 mln. due tu Fracturing |

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TABLE 6

| | | | | | | | Hard Coating Layer | L | | | | 10813 | Flank Wear |
|----------------|-----------|-------|---------------|-----------------|------------------|----------------------|--------------------|------------------|----------------------|-----------------------|----------------------|-----------------------|------------------------|
| Туре | Substrate | rate | Innermo | Innermost Layer | | Inner Layer | ayer | Oute | Outer Layer | Outerm | Outermost Layer | 5 | (mm) |
| | | · · · | Compo- | Crystal | Compo- sition | Crystal | Orientation | Compo- sition | Crystal Structure | Compo- sition | Crystel Structure | Continuous Cutting | Interrupted Cutting |
| | 15 | < | rit (| Granular | T.iCN | Elongated. Growth | (111) (220) (200) | A1203 | K: 941 | TIN (0.8). | Granular | 0.13 | 0.15 |
| 17 | 16 A | 4 | Tin | Granular | Tich | Elongated | (220) (111) (200) | A1203 | K: 851 | | | 0.15 | 0.14 |
| i | | | (0:5) | | (5.5) | Growth | | (6.1) | | | | | |
| | ۸ 71 | < | TiCN (0.8) | Granular | TiCN (11.2) | Elongated Growth | (111) (220) (200) | A1203 | N:1008 | TiCN- TiN (0.8) | Granular | 0.18 | 0.20 |
| | 16 B | | TiC- TiN | Granular | TiCN (8.3) | Elongated Growth | (1111) (200) (220) | A1203 (2.0) | K: 1004 | T£N (0.5) | Granular | 0.16 | 0.21 |
| Coated | 19 B | - | 7.iv | Granular | TiCN (4.8) | Elongated | (111) (220) (200) | A1203 | K:738 | | | 0.17 | 0.17 |
| | 20 C | | TiN (0.1) | Granular | TICN (10.2) | Elongated Growth | (220) (1111) (200) | A1203 | K: 558 | Tin (0.3) | Granular | 0.17 | 0.20 |
| <u>.</u> | 21 C | ļ., | Tic (0.4) | Granular | TiCN (5.5) | Elongated Growth | (220) (200) (111) | A1203 | K: 62% | T1N (0.5) | Granular | 0.20 | 0.22 |
| nt ion | 22 D | | T.iN (0.6) | Granular | TiCN (6.5) | Elongated Growth | (111) (220) (200) | A1203 | K: 734 | | | 0.13 | 0.16 |
| <u></u> | 23 D | | TiN (1.2) | Granular | TiCN (3.9) | Elongated Growth | (220) (111) (200) | A1203 (8.1) | K: 621 | | | 0.16 | 0.19 |
| <u></u> | 24 D | | TiCN (0.6) | Granular | 71CN (7.8) | Elongated | (111) (220) (111) | A1203 | K:1001 | | | 0.17 | 0.18 |
| <u>1~</u> | 25 K | | 1;N | Granular | 7.iCN (4.0) | Elongated Growth | (220) (111) (200) | A1203 | K: 1001 | | | 0.13 | (Milling) |
| <u></u> | 26 E | is | 7 in (0.3) | Granular | TiCN (3.5) | Elongated Growth | (1111) (220) (200) | A1203 | K:948 | TiN (0.3) | Granular | 0.15 | (Milling) |
| <u> ~</u> | 2.7 | | Tiv (0.7) | Granular | TiCN (4.5) | Elonyated Growth | (220) (111) (200) | A1203 | N: 1001 | T'IN (0.4) | Granular | 0.15 | 0.28 |
| I [~] | 28 C | | TiCN | Granular | TiCN ().1) | Elongated Growth | (111) (220) (200) | A1203 (0.7) | N:941 | TiN (0.2) | Granular | 0.14 | 0.27 |

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| | Monr | (mm) | | - | 5 | Chir | 0 | Chir | 0 | ichi | | rail | steer | | Layer | Separ | Failu | atter | ë. | Layer | Sepa | |
|---------|--------------------|------|-----------------|----------------|------------------|-------------------|-------|-------------------|----------|-------------------|--------|----------------|-------------------|------------------|-------|------------|-----------------|-------------------|------------------|-------|------------|--|
| | Flank Moar | | | Continuous | 0 10 | (Chipping) | 0.43 | (Chipping) | 0.51 | (Chipping) | | | after 13.2 | min. due to min. | Layer | Separation | Failure | after 14.5 | min. due co min. | Layer | Separation | |
| | | | Outermost Layer | | Structure | Granular | | | Granular | | | Granular | | | | | | | | | | |
| | | | Outerm | Compo- | n | 111N (0.8) | | | 14.0% | ZiF | (6.7) | Tin | 60.41 | | | | | | | | | |
| | | | Outer Layer | Crystal Compo- | sition Structure | a:1001 | | d: 1004 | 1 | K: 40 | | .000 | 1001:3 | | | | \$001.20 | | | | | |
| | | | Onte | Compo- | sition | A1203 | | 1203 | | A1203 | 17:71 | 0.14 | | | | | 5 | 577 | | | | |
| י מחמעו | Hard Coating Layer | | yer | Orientation | | (111) (200) (220) | | (220) (200) (111) | | (111) (200) (270) | | 1111/1000/1000 | 17711 (077) (007) | | | | 100011000111111 | (111) (200) (220) | | | | |
| | 3 | | Inner Layer | Crystal | e | | | Granular | | Granular | | - | Granular | | | | | Granutar | | | | |
| | | | | .00000 | sition | TICN | (8.1) | T.C. | 16.5 | 1 CN | (11.4) | | Tick | (8.4) | | | - | TICN | (4.2) | | | |
| | | | Insermost Layer | | Structure | | | Granular | | Granular | | | Cranular | | | | | Granular | | | | |
| | | | Inserm | | Compo | N.T. | 1.0) | TIN | 10.51 | TiCN | (0.7) | | TıC- | Tin | 11.4 | | | Ti N | (3.8) | | | |
| | | | Substrate | Symbol | | < | | < | | 4 | | | 0 | | | | | ø. | | | | |
| | Ī | | | | | 15 | | 76 | | 7 | | | 18 | | | | _ | 19 | | _ | | |
| | | | | | | | | | | | | | | | | | | | | | | |

Failure after 3.7 min. due to Practuring Failure after 10.. min. due to Chipping Separation Separation Failure Aiter 7.5 Min. due to Layer Separation Failure aiter 1.7 Min. due to Fracturing lure er B.1 rrupted o.53 ipping) 0.50 ipping) 0.58 ipping) Failure after 5.8 min. due to Chipping Failure

after 8.7

main. due to n

failure

frailure

frailu Granular Granular Tin (0.5) Tin (0.3) a:1001 a: 1001 a: 100% K: 401 K: 40% A1203 A1203 A1203 A1203 A1203 (1111) (200) (220) (220) (200) (111) (220) (200) (111) (200) (220) (111) (111) (200) (220) Granular Granular Granular Granular Granular TiCN (10.0) TiCN (7.6) 7 C. 8. TICN (5.4) TiCN (6.7) Granular Granular Granular Granular Granular TiCN (0.5) Tin (0.4) TiN (1.1) Tin (0.1) 71c (0.5) Δ ٥ ۵ ≈ 7 22 ဂ္ဂ lټ Coated Cemented Carbide Cutting Tools of Prior Art Type

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| _ | | | _ | _ | _ | | | | | | _ | | | | _, | _ | _ | | _ |
|---|--------------------|-----------------|--|------------------------|----------------------------|--------------------------|-------------------|-----------|-------------------------|-------------------|-----------|----------|--------------------|-------------------------|------------|---------------|-------------------|-------------------------|------------|
| | Flank Wear | (mm) | | Continuous Interrupted | בחנרווו) | | gui | | r 23.3 min. | · Separation | | Failure | after 0.1 | min. due to min. due to | Fracturing | Failure | after 0.2 | min. due to min. due to | Fracturing |
| | Flank | E | | Continuous | Cutting | Failure Atter 25. / min. | due to Chipping | (Milling) | Failure after 23.3 min. | Τ. | (Milling) | Failure | after 1.2 | min. due to | Chipping | Failure | after 3.0 | min. due to | Chipping |
| | | Outermost Layer | | Crystal | Structure sition Structure | | | | Cranular | | | Granular | | | | Granular | | | |
| | | Outerm | | сошро- | sition | | | | TIN | (0.3) | | Z | 6.6 | | | Nit | (0.3) | | |
| | | Outer Layer | | | | 2001.20 | | | | 501:3 | | 1 | α: 1001 | | | 300. | d: 100 | | |
| | | Oute | | Compo- | sition | 41.00 | (0.6) | | 100 | | | | | (\$.0) | | 1 | 50214 | 6.6 | |
| | Hard Coating Layer | yer | | Orientation | | 111111000110001 | 17771 (007) (077) | | 1000, 1000, 111 | (111) (200) (111) | | | (220) (2001) (111) | | | 1000,1000,111 | (077) (007) (111) | | |
| | ¥ | Inner Layer | | Crystal | Scructure | | Granutar | | | Granular | | | Granular | | | | Granular | | |
| | | | | 00000 | Sirio | | Z 2 | - | | ŽŲ. | 5.5 | | TiCN | (4.4) | | | TiCN | (3.2) | |
| | | Toyal Tacas | יייייייייייייייייייייייייייייייייייייי | | Crystai | Structure | Granular | | | Granular | | | Granular | | | | Granular | | |
| | | 1 | | | COMPO | S16100 | Z F | (6.5) | | Tin | (0.3) | | Nit | (9.0) | | | Tin- | Tich | 10.1) |
| | | | Substrate | Symbol | | | ы | | | .3 | | | | | | | U | | |
| | | | | | | | 25 | | | 92 | | | 2 | | | | 28 | | |
| | | | ተንፑር | | | | | | _ | Coated | Compared | , | _ | | Tools of | Prior Art | | | |
| | _ | | | | | | | | | | | | | | | | | | |

TABLE 7 (b)

TABLE 8

| | | | | | | Hard Coating Laver | ino Laver | | | į | } | | | |
|----------------|---------|--|-------------------|------------------|----------------------|--------------------|------------------|-------------------|------------------|-------------------|--------------|-----------------|------------------|-----------|
| | | | | | | | | | | | | | Flank Wear | Wear |
| Туре | sub- | ــــــــــــــــــــــــــــــــــــــ | Innermost Layer | | Inner Layer | yer | Pirst | Pirst | Outer Layer | Layer | Outermo | Outermost Layer | | |
| | Symbol | | | | | | Layer | ,er | | 1 | | | 1000 | |
| | | Compo- sition | Crystal Struc- | Compo- sition | Crystal Structure | Orientation | Compo- sition | Crystal Struc- | Compo- sition | Crystal Struc- | sition | Structure | nuous Cutting | rupted |
| 1 | 4 | Tin | Granular | Ticn | Elongated | (111) (220) (200) | Tic | Granular | A1203 | K:941 | Tin | Granular | 0.15 | 0.19 |
| : | | (0.9) | | (6.5) | Growth | | 5 | | (5.5) | | | | 87.0 | 0.18 |
| <u> </u> | < | TiN | Granular | TICN | Elongated | (220) (111) (200) | Tic (2.4) | Granular | A1203 | X:851 | | | | |
| | < | 6.5 | | TiCN (9.3) | Elongated Growth | (111) (220) (200) | TÍC (2.3) | Granular | A1203 | K:1001 | TiCN- TiN | Granular | 0.18 | 0.29 |
| | | - | | 20 | Floorarod | (1) 11 (200) (220) | Tic | Granular | A1203 | K: 1004 | Tin | Granular | 0.15 | 0.28 |
| 32 | a | Tic- | Cranulat | (4.5) | Growth | | (9.0) | | (1.7) | | (0.2) | | | |
| | | (1.1) | | | | 1006/1006/1111 | 2,5 | Granular | A1203 | F. 738 | | | 0.19 | 0.20 |
| Coated | 8 | Tin | Granular | 11CN | Growth | 10021102211111 | (1.0) | , | 4.0 | | | | | ; |
| Carbide 34 | U | Tir | Granular | TiCN | Elongated | (220) (111) (200) | Tic (3.2) | Granular | A1203 | K:551 | (0.0) | Granular | 0.19 | 0.24 |
| | 25 | 1.ic | Granular | TICN | Elongated | (220) (200) (111) | Tin | Granular | A1203 | K:621 | Tin | Granular | 0.25 | 0.25 |
| | | (0.7) | | (3.3) | Growth | (111) (220) (200) | Tic | Granular | A1203 | K:731 | | | 0.15 | 0.30 |
| Invention 36 | 9 | 2 0 | 1000 | (3.6) | Growth | | (5.8) | | 15.21 | | | | | |
| <u> </u> | 37 0 | | | TiCN | Elongated | (220) (111) (200) | TiCN (1.0) | Granular | A1203 | K: 621 | | | 0.16 | 72.3 |
| | 38 D | Tick | Granular | TICN | Elongated | (1111) (220) (200) | Tic | Granular | A) 203 | K:1001 | | | 0.16 | 0.21 |
| | | (0.4) | | 3.6 | Growth | 1000 | 16.51 | Craoular | 100 | .,,00 | | | 0.15 | (M.1.1ng) |
| <u> </u> | 39 E | 7. N | Granular | 7.CN | Elongated | (220) (1111) (270) | (1.5) | Ci anici ili | 10.51 | | | | i | 100 |
| _1*_ | 40 | | | TiCN | Elongated | (111) (220) (200) | T1C (1.6) | Granular | A1203 | K: 941 | TiN (0.2) | Granular | 0.14 | 10c1::(N) |
| | 41 | - | | Tich | Elongated | (220) (111) (200) | TICN | Granular | A1203 | K: 1001 | Tin | Granular | 0.16 | 0.25 |
| _ | | | | -1 | Growth | | 1 2 | 10000 | 6 | 1 | 27.5 | Granular | 0.14 | 0.24 |
| <u> </u> | 42 G | Tin | Cranular | 71C | Elongated | (111) (220) (200) | (1.9 | Granular | (0.6) | , | (0.3) | | | |

TABLE 9 (a)

| | | 4 | | | | | Hard Coating Loyer | ing Loy | ar | | | | | Flank Wear | Weor |
|-----------|------------|------------------|---------|-------------------|------------------|-------------------|----------------------------|------------------|-----------------------|------------------|----------------|------------------|-----------------|--------------|--------------|
| Туре | | strate Symbol | Innermo | Innermost Layer | | Inner Layer | Layer | Inter | Pirst Intermediate | Outer | Outer Layer | Outerm | Outermost Layer | (ww) | ī |
| | | | | | | | | 3 | Layer | | | | Cover at | Cont i puone | Interrunted |
| | | | sition | Crystal Struc- | Compo- sition | Crystal Struc- | Orientation | Compo- sition | Crystal Struc- | sition | Struc- ture | Compo- sition | Struc- ture | Cutting | Cutting |
| | 53 | < | Tin | Granular | TiCN | Granular | (111) (200) (220) | Tic | Granular | A1203 | α:1001 | Tin | Granular | 0.43 | 0.54 |
| | | | (1.0) | | 5.7 | | | ? | | 2.5 | | | | | |
| | or | V | Nit. | Granular | S C | Granular | (220) (200) (111) | Tic (2.1) | Granular | A1203 | α: 1001 | | | (Chipping) | (Chipping) |
| | <u> </u> ; | 1 | 50 | | Ž. | Granular | (111) (200) (220) | Tic | Granular | A170- | X:40V | TICN- | Granular | 0.50 | 0.48 |
| | - | • | | | (9.5) | | | (2.1) | | (2.1) | | Tin (0.6) | | (Chipping) | (Chipping) |
| | 7 | 6 | 1:0. | Granular | Tick | Granular | (200) (220) (111) | TIC | Granular | A1203 | α:1001 | TiN | Granular | Failure | Foilure |
| | : | | Z i | | (4.7) | | | (4.0) | | 13.81 | | 10.23 | | after 13.9 | after 8.8 |
| | | | (1.2) | | | | | | _ | | | | | min. due to | min. due to |
| | | | | | | | | | | | | _ | | Separation | Separation |
| | 1 | 1 | 3,5 | 200000 | 10.14 | Granular | (022) (002) (111) | Tic | Granular | A1201 | r.1004 | | | Pailure | Failure |
| | - - | 0 | 2 - | Cranorar | 4.8 | | | 1.23 | , | 100 | | | | after 11.1 | alter 6.2 |
| | | • | : | | : | | | | | | | | | min. due to | min. due to |
| Coated | | - | | | | | | | | | | | | Layer | Layer |
| Cemented | _ | | | | | | | | | | | | | Separation | Separation |
| Carbide | Ä | U | Tin | Granular | TiCN | Granular | (220) (200) (111) | Tic | Gronular | A1203 | a:1004 | NIL | Granular | Failure | Failure |
| Cutting | | | (0.1) | | (8.8) | | | (5.5) | | (1.1) | | (6.3) | | After 6.8 | after 1.4 |
| Tools of | • | | | | | | | | | | | | | min. due to | Fracturing |
| Prior Art | | | | | | | | | _ | | | | | Separation | |
| | ; | , | 27.6 | Cramilar | Z. | Granular | (200) (220) (111) | TIN | Granular | A1201 | K: 40% | Tin | Granular | Pailure | Failure |
| | ; | , | 9.6 | | (3.2) | _ | | (1.8) | | 6.6 | | (0.4) | | | ofter 4:1 |
| | _ | | | | | | | | | | | | | tre to | min. due to |
| | | | | | | | | | | | | | | Layer | Fracturing |
| | | | | | Ţ | _ | | | | | | | | Separation. | Pailing |
| | 36 | 2 | T. | Granular | Z i | Granular | (111) (200) (220) | יוני | Granular | 71203 | a:1001 | | | ofter 18.5 | after 9.3 |
| | _ | | (0.4) | | 6.5 | | | | | . 8 . | | | | min. due to | min. due to |
| | _ | | | | | | | | | | | | | Chipping | Chipping |
| | ; | | | | TiCN | Granular | (220) (200) (111) | TICN | Granular | A1203 | K: 408 | | | Failure | Failure |
| | : | , | | | (2.7) | | | 0.10 | | (8,1) | | | | after 16.8 | after 6.4 |
| | _ | | | | | | | | | | | _ | | min. due to | min due to |
| | | | | | | | | | | | | | | Chipping | Chiprim |
| | 23 | • | TICN | Granular | TiCN | Granular | Granular (111) (200) (220) | Tic | Granular | 1203 | a: 1001 | | | Failure | Failura |
| | | | (0.5) | | 15.71 | | | (5.5) | | (2.7) | | | | | atter 8.2 |
| | _ | | | | | | | | | | | | | Chipping | Chipping Chi |

| Flank Wear | (mm) | | Interrupted | | r 19.7 min. | guji | | r 19.3 min. | Separation | | Failure | ofter 0.1 | min. due to min. due to | Fracturing | Foilure | after 0.3 | min. due to min. due to |
|--------------------|-----------------|-----------------------|------------------------|-------------|----------------------------|-----------------|-----------|-----------------------------------|-------------------------|-----------|---------------------------------|-----------|-------------------------|------------|---|-----------|-------------------------|
| Flank | Ē | | Continuous Interrupted | | Fallure after 19.7 min. | due to Chipping | (Milling) | Granular Failure after 19.3 min. | due to Layer Separation | (Milling) | Failure | alter 1.4 | min. due to | Chipping | Failure | after 3.2 | min. due to |
| | Outermost Layer | | Crystal Struc- | | | | | Granular | | | Granular Failure | | | | Granular Failure | | |
| | Outers | | Compo | 81110n | | | | N.T. | (0.5) | | Tin | (0.3) | | | TiN | (0.2) | |
| | Outer Layer | | Compo- Crystal | | a:1001 | | | α:1001 | | | Q:1008 | | | | α:1001 | | |
| | Outer | | Compo- | | ۸1203 | 3 | 3 | A1203 | 1 | • | A1203 | | } | | ۸1203 | 10. | <u>:</u> |
| er | First | Intermediate Laver | Crystal | ture | Granular | | | Granular | | | Granular | | | | Granular A1203 | | |
| yel Pel | Ľ | Inte | Compo. | altion a | Tic | 1.4 | | Tic | (1.5) | | TiCN | 1.4 | | | Tic | (1.1) | |
| Hard Coating Layer | Inner Layer | | Orientation | | Granular (220) (200) (111) | | | Tich Granular (111) (200) (220) | | | TiCN Granular (220) (200) (111) | | | | Granular 1'iCN Granular (111) (200) (220) | | |
| | Inner | ٠ | Crystal | | | | | Granular | | | Granular | | | | Granular | | |
| | | | Compo- | sition | i. | | : | rion. | 19 (1) | : | F. | 0.4 | | | 1.ion | | : |
| | innermost Layer | | Compo- Crystal | 20100 | Granitar | | | | | | | | | | Granular | | |
| | Innerm | | Compo- | 21.100 | Z : f | 1 | | | | | | | | | Į. | 2 C F | (0.91 |
| ć. P | Strate | Symbol | | | | , | | | , | | 3 | | | | · | , | |
| | | | | | ٤ | ` | | Ş | | _ | 5 | | | | ; | : | |
| | Type | | | | | | | 10.00 | רחפרבת | Comented | Cartino | 00000 | 10012 | אנים: אני | | | • |
| | | | - | | | | _ | | | | _ | | | | | _ | |

TABLE 9 (b)

TABLE 10

| | | | | | | Hard | Hard Coaring Laure | | | | | | |
|-----------|-----|---------------------|----------------|---------------------|--------------------|----------------|--------------------|----------------------|-------------|--------|-----------------|-----------------|--------------------|
| | | | | | | | course paye | | | | | - | |
| Type | | Substrate Symbol | | Inner Layer | Layer | . 10. | Second | _ | Outer Layer | Outer | Outermost Layer | - | riank wear (mm) |
| | | | Сошро- | Crystal | Orientarion | 0 | 1 | + | | | | | |
| | | | sition | Structure | | sition | Structure | sition | Structure | Compo- | Crystal | Continuous | Interrupted |
| | \$ | ۷. | Ti Cs | Elongated | (111) (220) (200) | Ticho | Granular | A1203 | ╄ | Tin | Granular | CUCLING 0 15 | Cutting |
| | ŀ | | (8.4) | Growth | | 9.1 | | (2.0) | | (0.5) | | : | ; |
| | ÷ | < | 71CN (5. 7) | Elongated Growth | (220) (111) (200) | TiCNO | Granular | A1203 | K:851 | | | 0.16 | 0.17 |
| | 2,0 | 4 | E C | 13 | 1111111000 | | | (6.9) | | | | | |
| | | | (11.4) | Growth | (007) (770) (111) | (0.1) | Granular | (1.9) | X:1001 | Ticn- | Granular | 0.15 | 0.19 |
| | Ę | | í | | | | | | | (0.6) | | | |
| | | • | (8.2) | Growth | (220) (220) | TiCNO (0.1) | Granular | A1203 | K: 1001 | TiN | Granular | 0.14 | 0.20 |
| Coated | 47 | æ | TiCN (5.0) | Elongated | (111) (220) (1111) | Tico | Granular | A1203 | K:731 | | | 0.17 | 0.19 |
| Carbide | 4 8 | J | 4ics | Elongated | (220) (111) (200) | TiCo. | Sranil av | 500 | | | | | |
| Cutting | | | (10.2) | Growth | | (0.1) | - Craincia | 1203 | K: 558 | 21.5 | Granular | 0.18 | 0.21 |
| Tools of | 65. | U | Tick | Elongated | (220) (200) (111) | TICNO | Granular | A1701 | 6,639 | Zit | Granular | 333 | ; |
| e co | 1 | | (5.4) | Growth | | (0.1) | | 6.0 | * 70 . 4 | 9.0 | 78 70 70 70 | 3 | 67.0 |
| Invention | 20 | ٥ | 7.CV (6. 5. | Elongated | (1111) (220) (200) | TiCNO (0.1) | Granular | A1203 | X:948 | Tin | Granular | 0.13 | 0.18 |
| | 51 | ۵ | TiCN C. B. | Elongated | (220) (111) (200) | Ticno | Granular | A1203 | K: 621 | 10:61 | | 0.12 | 0.21 |
| | 25 | ۵ | 4 ic | Elongated | (111) (220) (200) | TiCNO | Granular | (8.2) | | | | | |
| 1 | 1 | | (1.7) | Growth | | (0.1) | | (2,4) | K: 1001 | | | 0.14 | 0.19 |
| | 3 | ш | TiCs | Elongated | (220) (111) (200) | Ticno | Granular | A1203 | K:1008 | | | 0.14 | (M) 11 (M) |
| | † | | | Crowth | | 2.0 | | (9.6) | | | | | |
| | | ù | Z 6 | Elongated | (111) (220) (200) | Ticho | Granular | A1203 | K: 944 | Tin | Granular | 0.16 (# | (Milling) |
| | 1 | 1 | | 1 | | | | (0.5) | | (0.3) | | | |
| | ; | - | 2.4 | Grewth | (002)(1111(022) | 6.1.0 | Granular | ارة الم و د و الم | K: 1001 | Tin | Granular | 0.12 | 91.0 |
| | 95 | U | TiCN | Elongated | (111) (220) (200) | TICNO | Granular | A1203 | K: 948 | TIN | Granular | 0.13 | 0.17 |

EP 0 685 572 B1

Failure after 10.1 min. due to Chipping

ន

Failure after 16.3 min. due to Chipping

a:1001

A1203

Granular

TICNO (0.1)

(1111) (200) (220)

Granular

TiCN (7.8)

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TABLE 11

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Failure after 5.3 min. due to Practuring Failure after 11.4 min. due to chipping Failure after 1.2 min. due to Fracturing Failure after 11.1 min. due to Layer 0.51 (Chipping) 0.55 (Chipping) Failure ofter 0.5 min. due to 0.54 (Chipping) Failure after 7.8 min. due to Separation Plank Wear (HE) Failure after 20.7 min. due to Chipping failure
after 8.2
min. due to
Layer
Separation
Failure
after 13.6
min. due to
Layer Pallure
after 17.5
min. due to
Layer
Separation
Fallure
after 14.0
min. due to
Layer
Ceparation Failure
ofter 18.9
min. due to
Chipping 0.43 (Chipping) 0.47 (Chipping) 0.42 (Chipping) Cont invous Separation Cutting Crystal Structure Granular Granular Granular Granular Granular Granular Outermost Layer Compo-sition TiN (0.4) TIN (0.5) TiN (0.5) TIN (0.2) Tick-Tin (0.7) Crystal Structure a: 1001 a: 1001 $\alpha:100$ a: 100% a: 1001 a: 1001 K: 401 K: 401 X: 404 Outer Layer A1203 A1203 A1203 13.20 A1203 A1203 A1203 (6.1) A1203 (1.8) Second
Intermediate Layer
Compo- Crystal
strion Structure Hard Coating Layer Granular Granular Granular Granular Granular Granular Compo-sition richo (0.1) TiCNO (0.1) TiCNO (0.1) TiCNO (0.1) TICNO 10.1) TiCNO (0.1) 71C0 TiCO (111) (200) (220) (220) (200) (111) (111) (200) (222) (200) (220) (111) (220) (200) (111) (200) (220) (111) (111) (200) (220) (111) (200) (220) (111) (200) (220) Orientation Granular Granular Granular Crystal Structure Granular Granular Inner Granular Granular Sition TiCN (8.2) TiCN (5.5) TiCN TiCN (10.3) TiCN (7.5) TiCN (5.2) TiCN (6.6) TiCN (8.3) 7;CN (4.8) Substrate Symbol **C** a 2 20 48 47 5 9 7 4 Coated Cemented Carbide Cutting Tools of Type

TABLE 11 (b)

| | | | | | | Hard C | Hard Coating Layer | ! ! | | | | Flank | Flank Wear |
|-----------|-----|-----------|--------|------------------|----------------------------|----------|--------------------|--------|-------------------------|--------|------------------|-------------------------|--------------------------|
| 1)ype | | Substrace | | Inner Layer | ayer | Š | Second | Oute | Outer Layer | Outerm | Outermost Layer | . | (mm) |
| | | Sympol | | | | Intermet | incermediate tayer | | | | 1 | | |
| | | | -0000 | Crystal | Orientation | -odwob | Crystal | Compo- | Crystal Compo- | Compo- | Crystal | Continuous | Continuous Interrupted |
| | | | sirjon | sition Structure | | sition | | sition | sition Structure sition | sition | Structure | Cutting | Cutting |
| | 1 | | 2016 | | (220) (200) (111) | TICNO | Granular | A1203 | a:100% | | | Fallure after 26.9 min. | r 26.9 min. |
| | 2 | د | (4.2) | | | (0.1) | | (0.5) | | | | due to Chipping | ing |
| | I | | | | 1000, 1000, 1111 | ON U. H | ye Lines | ģ | 2000 | 21.1 | Granular | Failure after 24.2 min. | r 24.2 min. |
| Coated | 3 | | 4104 | Granular | Granular 111111200112201 | | 18101010 | 22.0 | d: 100 | 6 9 | | due to Laver Separation | Separation |
| Cemented | | | 64.0) | | | | | ÷: | | | | (Milling) | |
| arbide | | | | | | | | | | 77.6 | 20011100 | Falluro | Failure |
| 001:11 | 8.8 | 1. | T.C. | Cranular | (220) (200) (111) | 27 | Cranular | A1203 | α:1001 | 47. | 107011010 | | |
| | ` | • | 13 47 | | | (0.1) | | (0.3) | | (0.4) | | after 2.0 | ofter 0.2 |
| 10 5 100 | | | | | | | | | | | | min. due to | min. due to min. due to |
| Prior Art | | | | | | | | | | | | Chipping | Fracturing |
| - | I | ļ | 100 | 1 1 1 1 1 1 | 102011000111111 | CNU | Granular | 10014 | 2.1001 | Hir | Granular Pailure | Pailure | Failure |
| | å | 3 | 3 6 | | | (0.2) | | 6.0 | | (0.3) | | after 5.2 | after 0.7 |
| | _ | | - | | | | | | | | | min. due to | min. due to min. due to |
| | | | | | | | | | | | | Chipping | Fracturing |

TABLE 12

| Ę. | Inter- rupted Cutting | 0.14 | 0.13 | 0.15 | 91.0 | 0.17 | 0.19 | 12.0 | 0.15 | | 0.15 | 4illin() | Killing) | 91.9 | 0.15 |
|------------------------|---|--|--|--|--|--|---|--|--|--|---|--|---|--|--|
| E) | Conti- nuous Cutting | 0.13 | 0.15 | 0.14 | 0.13 | 0.16 | 0.17 | 0.20 | 0.12 | 0.11 | 0.13 | 0.12 | 0.14 | 0.11 | 0.11 |
| ist Layer | Crystal Structure | Granuler | | Granular | Granular | | Granular | Granular | Granular | | | | Granular | Granular | Granular |
| Outermo | Compo- sition | TIN (0.5) | | TICN- TIN (7.0) | TiN (0.3) | | TÎN (0.3) | TiN (0.5) | TÍN (0.2) | | | | TÎN (0.3) | TIN (0.5) | Tin (0.2) |
| Layer | Crystal Struc- ture | K:948 | x:851 | K: 1001 | K:1001 | У . Г. У | K:551 | K:621 | K:941 | K: 621 | K; 1001 | X:1001 | K: 948 | K: 1001 | K: 941 |
| Outer | Compo- sition | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 |
| cond nediate ver | Crystal Struc- | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granulor | Granular | Granular |
| Intera | Compo- sition | TiCNO (0.1) | TiCNO (0.1) | TiCNO (0.1) | TiCNO (0.1) | T1C0 | 71CO (0.1) | TiCNO (0.1) | TiCNO (0.1) | TiCNO (0.1) | TiCNO (0.1) | TiCNO | TiCNO (0.1) | TiC0 | TiCNO (0.2) |
| ayer | Orientation | (111) (220) (200) | (220) (111) (200) | (111) (220) (200) | (111) (200) (220) | (111) (220) (200) | (220) (111) (200) | (220) (200) (111) | (111) (220) (200) | (220) (111) (200) | (111) (220) (200) | (220) (111) (200) | (111) (220) (200) | (220) (111) (200) | (111) (220) (200) |
| Inner L | Crystal Structure | Elongated | Elongated Growth | Elongated Growth | Elongated | Elongated | Elongated | Elongated | Elongated | Elongated | Elongated | Elongated | Elongated Growth | Elongated Growth | Elongated Growth |
| | Compo- sition | TiCN | 7iCN | TiCN (11.5) | TiCN (8.2) | TiCN (4.9) | TiCN | TiCN (5.3) | TiCN (6.4) | T1CN | TiCN (7.8) | 7 iCN | TiCN | TiCN (4.6) | TiCN |
| st Layer | Crystal Struc- | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granular |
| Innermo | Compo- sition | Tin | Tin | 1)CN (0.8) | TiC- TiN | Tin | 7 T | Tic | Nit | TiN | TiCN | Tin | rin (E.0) | TiN (7.0) | Tin- |
| strate Symbol | | 4 | < | < | 60 | ۵. | U | U | ۵ | a | a | :0 | ü | 64. | U |
| | | 2 | 85 | 59 | 9 | 3 | 3 | 3 | 59 | 8 | 99 | 159 | 8 | 69 | 20 |
| Туре | | | | | | Coated | Carbide | Tools of | Invention | | - | | | | |
| | strate Innormost Layer Inner Layer Symbol | Symbol Symbol Compo- Crystal Compo- Crystal Sition Struct- sition Structure Structore Innermost Layer Layer Compo- Crystal Compo- Crystal Orientation Compo- Crystal Compo- Crystal Compo- Structure Sition Structure Structore Sition Structure Second Outer Layer Lay | Symbol Compo- Crystal Compo- Crystal Compo- Structure Struct | Symbol Symbol Compo- Crystal Conting Cutting Cutting Cutting Cutting Cutting Cutting Cutting Cutting Cutting Compo- Crystal Conting Cutting Cutting Cutting Cutting Cutting Cutting Cutting Cutting Compo- Crystal Conting Cutting Cutti | Symbol Compo- Crystal Compo- Cry | Symbol Compo- Crystal Compo- Cry | Symbol Strate Innormost Layer Inner | Symbol Crystal Compo- Crystal Crystal Compo- Cr | Symbol Strate Innormost Layer Inner Layer Compo- Crystal Compo- | Symbol Compo- Crystal Compo- Cryst | Symbol Compo- Crystal Compo- Crystal Crimation Campo- Crystal Compo- Crystal | Symbol Compo- Crystal Compo- Cryst | Symbol Compon Crystal | Symbol Composite Layer Inner Layer Second Outer Layer Composite Captable C | Strict Innocrmost Layer Inner Layer Inner Layer Inner Layer Inner Layer Composition Crystal Crystal Crystal Composition Crystal Crys |

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| Туре | Sub- strate Symbol | . 8 5 | Innermosi Compo-St | Innermost Layer Compo- Struc- Struc- | Compo- sition | Inner Layer Crystal Or | Hard Coating Layer Layer Sec Intern Lace Lace Orientation compo- sition | Sec Interm La Compo-sition | Second Second Intermediate Layer Layer Crystal tton | Outer Layer Compo- Cryst | Layer Crysta | Outermc Compo- eltion | Outermost Layer Compo Crystal Struc- | Flank Wear (mm) Continuous Inter | Wear n) Interrupted Cutting |
|---|--------------------------|-------|------------------------|---------------------------------------|------------------|------------------------|---|----------------------------|---|--------------------------|-----------------|-----------------------------|---------------------------------------|---|---|
| \ <u>\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\</u> | S7 A | | | Cranular | TiCN | ture Granular | (1111) (200) (220) | TiCNO (0.1) | Cranular | A1203 | ture α:1001 | TiN (0.5) | Granular | 0.38 (Chipping) | 0.51 (Chipping) |
| J | × × × | | z 5 | Granular | 71CN (5.3) | Granular | (220) (200) (111) | 1_ | Granular | A1203 | a:100% | | | 0.41 (Chipping) | 0.49 (Chipping) |
| J**. | 89 A | | | Granular | TiCN (11.3) | Granular | (111) (200) (220) | Ticno (0.1) | Granular | A1203 | K: 408 | TiCN- TiN (0.6) | Granular | 0.40 (Chipping) | 0.54 (Chipping) |
| 1. ⁻ | 09 | | TIC- G TIN (1.5) | Granular | TiCN (8.1) | Granular | (200) (220) (111) | TiCNO (0.1) | Granular | A1203 (2.2) | a:1001 | TiN (0.3) | Granular | Failure after 18.8 min. due to Layer Separation | Failure after 12.3 min. due to Layer Separation |
| -1 | 61 B | | Tin G | Granular | TiCN (4.8) | Granular | (111) (200) (220) | Tico (0.2) | Granular | A1203 (5.0) | α:1001 | | | Failure after 15.1 min. due to Layer Separation | railure after 8.6 min. due to Layer Separation |
| Cutting Cutting Tools of Prior Art | 62 62 | | Tin (0.1) | Granular | TiCN (10.2) | Granular | (220) (200) (111) | 1ico (0.1) | Granular | A1203 (5.0) | a: 100% | TÍN (0.3) | Granular | Failure after 9.0 min. due to Layer Separation | Feilure after 1.7 min. due to Fracturing. |
| | 9 | F 0 | ပ္ မ ွ | Granular | TiCN (5.4) | Granular | (200) (220) (111) | TiCNO (0.1) | Granular | A1203 | K: 401 | TIN (0.6) | Granular | Failure after 14.6 min. due to Layer Separation | Failure, after 5.9 min. due to Fracturirg |
| | 0 | 1 5 | z 5 | Granular | TiCN (6.6) | Granular | (1111) (200) (220) | TiCNO (0.1) | Granular | A1203 | α:1004 | | | Failure ofter 21.4 min. due to Chipping | Failure after 12.3 min. due to Chipping |
| | 2.9 | = - | z ñ | Granular | 11CN (3.9) | Granular | (220) (200) (111) | TiCNO (0.1) | Granular | A1203 (8.2) | K:408 | | | Failure after 19.5 min. due to Chipping | Failure after 9.3 min. due to Chipping |
| 1 | 0 99 | | 71CN (0.5) | Granular | TiCN (7.7) | Granular | Granulae (111) (200) (220) | TiCNO (0.1) | Granular | A1203 (2.3) | a:1001 | | | Failure after 17.1 min. due to Chipping | Failure . after 16,8 min. duf :> |

| _ | | _ | | Ξ | | | т | | _ | ╗ | | _ | | | | 0 | 7 | | | 0 | - 1 | |
|---|--------------------|-----------------|------------------------|-------------|---------------|------------------|--------|-------------------------|---------------------------|-----------|----------------------------------|-------------------|--|------------------|-------------------|-------------|----------|------------------|----------------------------|-------------------------|------------|---|
| | Vie & C | Ê | | interrupted | | ימנריוו י | | r 28.0 min. | ing | | r 24.8 min. | Contraraco | e de la companya de l | Failure | after 0.2 | | | Failure | atter 0.9 | min. due t | Practuring | |
| | Flank Wear | (EE) | | 2110110 | 2011411000 | Cutting | | Failure after 28.0 min. | due to Chipping | (Milling! | Gradular Failure after 24.8 min. | | (Milling) | Pailure | ofter 2.5 | min. due to | Chipping | Failure | after 5.7 | min. due to min. due to | Chipping | |
| | | Outermost Layer | | | | Struc- ture | | | | | Cranilar | | | Granular Pailure | | | | Granular Failure | | | | |
| | | Outerm | | | | sition | | | | | 1 | 1 | (e.9) | 1 | | <u>;</u> | | Z | | : | | |
| | | Γ | | | Crysta |) Struc- | ture | 0000 | 1001 | | | a: 100% | | | a: 1001 | | | - | a: 1004 | | | |
| | | Outer Laver | | | Compo- Crysta | sition | | 100 | 50710 | (0.6) | | A1203 | (0.4) | _[| A1203 | (0.4) | _ | ┸ | | (0.9) | | |
| | | | Second Intermediate | Layer | Crystal | Struc- | ture | | Granutar | | | Granular | | | Granular | | | | Granular | | | |
| | ig Layer | | Inter | 7 | | Compo- | | | Ticno | 9.1 | | CNC | (0.1) | | 4100 | (0.1) | | | | (0.5) | | |
| | Hard Coating Layer | | yer | | | Orientation | | | (220) (200) (111) TiCNO | | | 1000, 1000, 1111, | (111) (200) (210) | | (220) (200) (111) | | | | Granular (111) (200) (220) | | | |
| | | | Inner Layer | | | Crystal Struc- | ture | | Granular | | | | Granular | | Cramilar. | | | | Granular | | | _ |
| | | • | | | | Compo- Crystal | | | Tick | 5 | | | 7. CZ | | 30.0 | 14.53 | | | NO: F | (3.3) | | |
| | | | Innermost Layer | | | Crystal | ture | | 200000 | Granotae | • | | Granular | | | Granulas | | | 1,100 | | | |
| | | | Innerm | | | Compo | sition | | | 212 | 5.0 | | T.I. | ? O | | 21. | ; ; | | ١ | 2 2 | 6 | |
| | | 4.5 | strate | Symbol | | | | | | w | | | Ε. | | | î. | | | | و | | _ |
| | ŀ | | | _ | | | | _ | 1 | 63 | | | 8 | | | 69 | | | 1 | 2 | | |
| | | | Type | | | | | | | | | _ | 1_ | Cemented | Carbide | Cutting | Tools of | Prior Art | _1 | | | |
| | L | | | | | | | | _ | _ | - | | | | | | | | | | | _ |

TABLE 13 (b)

| | | | | | | Hard Coating Layer | ing Layer | | | | | | Plank Wear | - No a C |
|--------------|--------------|----------|-------------|--------------------|---------------|--------------------|---------------|--------------|-------------|---------|--------------|------------------|------------|--------------|
| | Sub- | | | | | | | | | | 20.40 | Out ormost Laver | (uuu) | |
| 900 | strate | L | Inner Layer | iyer | 1 | First | Sec | Second | Onter rayer | Tayer. | 7000 | 100 | | _ |
| | Symbol | , | | | Intern | Intermediate | Intern | Intermediate | | | | | | |
| | | | | | 97- | | 1 | 10000 | -00000 | Crystal | Compo- | Crystal | Cont 1 - | Inter- |
| | | -осшо | Crystel | Orientation | -odmon | Struc- | sition | Struc- | sition | Struc- | sition | Structure | snonu | rupted |
| | | S1 C 100 | ture. | | | ture | | ture | | ture | | | Cutting | Cutting |
| 1- | 4 | Ticn | Elongated | (1111) (220) (200) | Tic | Granular | TiCNO | Granular | A1203 | K1948 | (0.2) | Granular | 97.0 | 0. 0 |
| - | | (6.3) | Growth | | (3.5) | | | | 1 | | | | 61 0 | 0.19 |
| 2 | < | Tick | Elongated | (220) (1111) (220) | 7ic | Granular | TicNO | Granular | A1203 | K: 85% | | | | |
| [: | 4 | | r) onnot ed | (111) (220) (200) | Tic | Granular | TiCNO | Granular | A1203 | K: 1001 | TiCN- | Granular | 0.16 | 0.21 |
| _ | • | (9.4) | Growth | | (5.0) | | 10.1 | | (2.1) | | 0.7 (5.0) | | | |
| _ ~ | | TiCN | Elongated | (1111) (200) (220) | Tic | Granular | Ticno | Granular | A1203 | K: 1001 | TIN. | Granular | 0.15 | 0.23 |
| | | (4.6) | Growth | | (3.8) | | (0.3) | | 8.5 | | 3 | | | |
| Coated 75 | a | TiCN | Elongated | (111) (220) (200) | TiC (1.4) | Granular | 71C0 (0.1) | Granular | A1203 | K: 731 | | | 0.13 | 1.5 |
| | \downarrow | 20.5 | Flondared | (220) (111) (200) | Tic | Granular | 7100 | Granular | ٨١203 | K: 551 | LIN | Granular | 0.20 | 0.24 |
| Carbide | , | (6.6) | Growth | | (1.0) | | (0.2) | | 10.11 | | 6.9 | | | ; |
| Tools of | v | TiCN | Elongated | (220) (200) (111) | Tin | Granular | TICNO | Granular | A1203 | K: 621 | 1 in | Granular | 0.25 | 57.5 |
| - i | | 5 | Growth | 1000 | 17.27 | 14 (11002) | UNU | Granular | 9 6 | 4.7.4 | TIN | Granular | 0.15 | 0.19 |
| Invention 78 | ۵ | Z Z | Elongated | (111) (220) (111) | (2.9) | Terinital. | (0.1) | | (5.2) | | (0.5) | | | |
| <u> </u> 2 | 0 | 11CN | Elongated | (220) (111) (200) | TICN | Granular | Ticho | Granular | A1203 | K:621 | | | 0.14 | 0.22 |
| | | (2.4) | Growth | | (0.6) | | 1 | | 9.6 | | | | 2.0 | |
| 8 | ٥ | Tick | Elongated | (1111) (220) (200) | T1C | Granular | TiCNO | Granular | A1203 | K: 1001 | | | } | |
| | | (5.5) | Growth | 1000 | 0 1 | 10000 | ONO | Granular | A1503 | 1001 | | | 0.15 | (Milling) |
| 9.1 | ш | TiCN | Elongated | (220) (111) (220) | 1.3 | לו מותום ו | (0.1) | | (0.5) | | | | | |
| <u>]</u> | 1 | T.O. | Elongaled | (1111) (220) (200) | Tic | Granular | TICNO | Granular | 41203 | K:941 | z ć | Granular | 6.13 | (Mil: ir.gl. |
| | | (2.3) | Growth | | (2.5) | | (0.1) | | 9 | | 10:01 | 1 | 3 | 100 |
| 8 | 3 | TiCN | Elongated | (220) (111) (200) | T1CN (1.2) | Granular | 4i.0 | Granular | A1203 | K: 1001 | (0.3) | Granular | | 23:0 |
| - 2 | 0 | Tich | Elongat.ed | (111) (220) (200) | Tic | Granular | TICNO | Granular | A1203 | K:948 | z ć | Granular | ? ? | 0.19 |
| | _ | 6 | Creery | | ē. | _ | 17.0) | | (0.6) | | | | | |

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| 5 | |
|----|---|
| 10 | |
| 15 | • |
| 20 | |
| 25 | |
| 30 | |
| 35 | |
| 40 | |
| 45 | |

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TABLE 15 (a)

| Flank Wear | (mn) | Continuous Interrupted Cutting Cutting | 0.43 0.53 (Chipping) | 1 | | ╁ | min. due to min. due to | Layer Layer Separation Secaration | +- | after 12.1 after 6.3 | Layer Layer | uo | Fallure | airet 6.0 airet 1.2 | | Separation | Т | | due to | Separation Practucing | Failure Failurg. | after 18.6 after 9.5 | 3 | 1 | Fallure Failure | | Chipping Chipping | П | after 15.9 after C.4 | - |
|--------------------|---------------------------------|--|----------------------|-------------------|--|-------------------|-------------------------|--------------------------------------|--------------------|----------------------|-------------|---------|-------------------|---------------------|---|------------|-------------------|--------------|------------|-----------------------|-------------------|----------------------|---|-----------------|-----------------|-------|-------------------|--------------------|----------------------|---|
| | Outermost Layer | Crystal Struc- ture | Granular | | Granular | Granular | • e | <u></u> | | 40 1 | | ı v. | Granular | 9 6 | | Š | Granular F | 40 | <u>e</u> . | 3 0 | Granular | r | E | | _ | 9 6 | 5 | Fo | <u> </u> | • |
| | Outer | Compo- sition | TIN (0.3) | | Tich- Tin | Z i | 7.0 | | | | | | Zir | | | | Tin | ÷. | | | Tin | (0.3) | | | | | | | | |
| | Outer Layer | Crysta 1 Struc- ture | a: 1001 | a: 1001 | K:401 | a: 1001 | | | a: 1001 | | | | a: 1001 | | | | K:401 | | | | a: 1001 | | | 1 | ж: ф0 | _ | | a: 1001 | | |
| | Outer | Compo- sition | A1203 | A1203 | A1203 | A1203 | 6.1 | | A1203 | (7.6) | | | A1203 | (2.1) | | | 11203 | (0.8) | | | A1203 | (5.1) | | 1 | 503 | (8.1) | | A1203 | 15.51 | |
| ١ | Second Intermediate Laver | Crystal Struc- ture | Granular | Granular | Granular | Granular | | | Granular | | | | Granular | | | | Granular | | | | Granular | | | | 10101010 | | | Granular | | |
| ng Laye | Inter | Compo- sition | TiCNO (0.1) | T1CNO | TiCNO (0.1) | TICNO | | | Tico | | | | 7 i C | | | -+ | _ | - ?: 0 | | | ⊢ | (0.1) | | 0.00 | | : | | TICNO | 17.0) | |
| Hard Coating Layer | First Intermediate Laver | Crystal Struc- ture | Granular | Granular | Granular | Granular | | | Granular | | | | Granular | | - | -+ | Granular | | | | Granular | | | 1 | | | | Granular | | |
| | Inter | Compo- mition | Tic (3.2) | Tic (2.0) | 7ic (2.1) | 710 | : | | Tic | (1.2) | - | -1 | 7.10 | : : | | + | _ | | | | Tic | (5.8) | | + | | | | Tic | 16.31 | |
| | Layer | Orientation | (111) (200) (220) | (220) (200) (111) | (111) (200) (220) | (200) (220) (111) | | | (1111) (200) (220) | | | | (220) (200) (111) | | | | (200) (220) (111) | | | | (1111 (200) (220) | | | 111111000010000 | | | | (1111) (200) (220) | | |
| | Inner Layer | Crystal Struc- ture | Granular | Granular | Granular | Granular | | | Granular | | | | Granular | | | _ | Granular | | | | Granular | | | 1 | _ | | | Granular | | |
| | | Compo- sition | TiCN (6.2) | TiCN (3.0) | TiCN (9.3) | TiCN | | | TiCN | 9. | | | 71CN | : | | | ۲ ; | 13:51 | | | TIC. | 5. | | 20.6 | 2.4 | | | TiCN | | |
| Sub. | Symbol | | ٧ | < | < | 9 | | | 8 | | | | U | | | | U | | | | ۵ | | | , | | | | a | | |
| | | | 11 | 72 | 23 | 7.4 | | | 2.2 | <u> </u> | | | 26 | _ | | | ۲, | | | | 9 | | | ļ | : | | | 80 | | |
| | <u>ځ</u> . | | | | | · . | | | | Coated | Cemented | Carbide | Tools of | Prior Art | | | | | | | | | | | | | | | | |

| | | Flank Wear (mm) | | Continuous Interrupted | | | Failure after 23.2 min. | pping | | Granular Failure afron 20 1 -i- | due to Layer Separation | | Failure | | _ | Fracturing | Pailure | after 0.3 | min. due to min. due to |
|-------|--------------------|-----------------------|---------|---------------------------|--------|----------------------------|-------------------------|-----------------|-----------|---------------------------------|-------------------------|-----------------|--------------------|-----------|------------|----------------------------|------------------|-----------|-------------------------|
| | | | | Continuou Cuttino | | | Failure at | due to Chipping | (Milling) | Failure | due to Lay | (Milling) | Failure | ofter 1.6 | min. due t | Chipping | Failure | after 3.5 | min. due to |
| | | Outermost Layer | | Crystal Struc- | ture | | | | | Granular | | | Granular Failure | | | | Granular Failure | | |
| | | Outer | | -oduo2 | | | | | | Tin | (0.2) | | Tin | (0.2) | | | Ę | 9.5 | |
| | | Outer Layer | | Compo- Crysta sition 1 | Struc- | ture | a: 1001 | | | Q: 100% | | | α: 1001 | | | | a: 1001 | | |
| | | Onte | | Compo- sition | | | ۸1203 | (0.4) | | A1203 | (0.4) | | ۸۱20) | (0.3) | | | · A1203 | (0.7) | |
| | 0 | Second | Layer | Crystal Struc- | cure | | Granular | | | Granular | | | Granular | | _ | | cranutar A1203 | | |
| | ing Lay | Inte | | Compo- | | | Ticno | 10.1 | | _ | (0.1) | | 1100 | 3.5 | | 0.10 | 2 | : | |
| 17.00 | natu coating Layer | First Intermediate | - Art | Struc- | 9 100 | | Granular Ticho | | | Granular | | | TICN Granular | | | Cramina. | | | |
| | | Inte | | Compo- | | 9 | 2 5 | | 1 | | 6.1 | _ | | | | ١ | | | |
| | | Layer | 1000000 | Ottentanton | | Granular (220) (200) (111) | 1111 (000) | | | (077) (007) (111) | | 111111000110001 | (1111) (007) (077) | | | Granular (111) (200) (220) | | | |
| | | Inner Layer | Cryerel | Struc- | | Granular | | | | מומומו | | Gradular | | | | Granular | | - | |
| | | | Compo | sition | | Tick | (5.4) | | NJ:L | (2.5) | | TiCN | 0.5 | | | TiCN | 3.B) | | |
| | Sub- | Symbol | | | | ы | | | į. | , | | L | | | | ن | • | | |
| | | | | | 1 | 8 | | | 82 | _ | | 83 | _ | | | 84 | | | 1 |
| | _ | Туре | | | | _ | | | Coated | Cemented | Carbide | Cutting | Tools of | Prior Art | | | | | |

TABLE 15 (b)

TABLE 16

| | Flank Wear | (mm) | Interespted | _!_ | 0.18 | 0.20 | 0.22 | 0.13 | 0.23 | 0.24 | 0.13 | 0.21 | 0.20 | (Mt.11:ng) | (Hilling) | 6.19 | 0.18 |
|--------------------|------------|---------------------------------|---------------------------|---------------------|---------------------|---------------------|----------------------|---------------------|-------------------|--------------------|---------------------|---------------------|-------------------|-------------------|---------------------|---------------------|-------------------|
| | Fla | | Cont innous Cut t ing | 0.15 | 0.17 | 0.15 | 0.14 | 0.18 | 0.18 | 0.23 | 0.13 | 0.13 | 0.14 | 9.14 | 0.16 | 0.13 | 0.13 |
| | | Outermost Layer | - | Granular | | Granular | Gramilar | | Granuler | Granular | | | | | Granular | Gramilar | Granular |
| | | 13 1 | Compo- sition | Tin (0.2) | | TiCN. | TiN (0.2) | | Tin (0.3) | ris 0 | | | | | 7 in | N (5.0) | Tin Co. 2 |
| | | Outer Layer | | X: 941 | K: 858 | K: 1001 | K:1001 | K:738 | K:551 | K:621 | K: 734 | K: 621 | K: 1001 | K: 1001 | K: 941 | K:1001 | K: 941 |
| | | Oute | Compo- sition | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 |
| | | Second Intermediate Layer | | Granular | Granular | Gramlar | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granuler |
| 5 | | Inte | Compo- sition | TICNO (0.1) | TiCNO (0.1) | T1CNO (0.1) | TiCNO (0.1) | 11C0 | Tico (0.2) | TiCNO | TiCNO | TiCNO (0.1) | TiCNO (0.1) | TiCNO | Ticno (0.1) | 1100 | TÍCNO (0.2) |
| Hard Coating Loyer | | First Intermediate Layer | Crystal Struc- | Granular | Gramular | Gramular | Granular | Gramlar | Granular | Granular | Granular | Granular | Granular | Granular | Gramular | Granuler | Granular |
| lard Co | | Inter | compo- eftion | 1.C 0.0 | TiC (2.3) | TiC (2.1) | Tic (3.8) | TiC (1.2) | Tic (3.0) | TiN (1.7) | TiC (2.8) | TICN (1.2) | Tic (2.5) | TiC (1.4) | 71C (1.5) | 71CN | Tic (1.0) |
| | | ayer | Orientation | (111) (220) (200) | (220) (111) (200) | (111) (220) (200) | (111) (200) (330) | (111) (220) (200) | (220) (111) (200) | (220) (200) (1111) | (111) (220) (200) | . (220) (111) (200) | (111) (220) (200) | (220) (111) (200) | (111) (220) (200) | (320) (1111) (300) | (111) (220) (200) |
| | | Inner Layer | Crystal | Elongated Growth | Elongated Growth | Slongated Growth | Elongated | Elongated Greath | Elongated | Elongated | Elongated Growth | Ţ. | Elongated | Elongeted | Elongated Growth | Elongated Growth | |
| | | | Comps- | TiCN (6.4) | TiCN (3.0) | 11CN (9.2) | TiCN (4.7) | TiCN (4.8) | T.iCN (6.7) | TiCN (3.2) | TiCN (3.6) | TiCN (2.3) | TiCN (5.4) | TiCN (2.6) | TICN (2.5) | TiCN (3.2) | TiCN (1.9) |
| | | Layer | Crysta) Struc- ture | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granular | Granuler | Granular | Granular | Granuler | Granular |
| | | 3 | Compo- sition | TiN (0.8) | 1ix (0.4) | TiCN (0.7) | TiC- TiN (1.2) | T'IN (1.51 | TiN (0.1) | Tic (0.7) | TiN (0.6) | TiN (1.0) | TiCN (0.4) | TiN (0.3) | TiN (0.3) | TiN (0.5) | TiCN |
| | . one | Symbol | , | 4 | ∢ . | < | ឡ | 5 | C | C | D | ٥ | ٥ | ភ | ε. | ٤. | U |
| | | | | 88 | 8 | 8 | 8 . | 89 | 90 | 9.1 | 92 | 93 | 94 | 68 | 96 | 9.7 | 86 |
| | | | | | | | - | Coated Coated | Cutting | Tools of | Invention | | | | | | |

| | ſ | | | | | | | | • | | | | | | | | | • | | | | | | | | | |
|-----------|----------------------------|-------------|---------------------------------|---------------------------|---------------------|--------------------|-------------------|------------|-----------------------|----------------------|-----------------|-------------|-----------------------|--|-----------------------|-------------|------------------|---------------|----------------------|-------------------------|------------|--------------------|---------------------------|--|----------------------|-----------------|--|
| 5 | | Flank Wear | (mm) | | - | <u>"</u> | 1Chipping) | 0.39 | Failure | Hin. de to | Failure | min. due to | Separation Failure | after 1.5 Aln. due to Fracturing | Failure | min. due to | rallure | min. due to | rallure ofter 7 2 | min. due to Chipping | | Chipping | Intillings | O 7 min. | Fellure | Freety Ind | failure after 6.4 Aln. due to |
| 10 | | FIG | | Cant invous | Cutting 0.41 | tchipping | (Chipping) | (Chipping) | Pailure ofter 15:1 | nin. due to Layer | Fellure | ain. due to | Seperation Failure | afn. due to | Failure after 12.5 | • | \neg | ain. due to | | | ofter 16.3 | phing | due to Chipping (Hilling) | failure after 20 7 min. Oue to Leyer Separation | Feilure F | 3 | failure fa after 3.9 af min. due to ma |
| | | | TOB E | Crystal | וני ביני ני ביני | Granular | - | Granulae | Granuler | | | | | | Granular | | 1 | | | - 01 | | 513 | : 8 | _ | | ŤĚ | |
| | | | Outermost | Compo | | (0.2) | 1 | | - | | \vdash | | _ | | + | | 1 | | | 1 | | \perp | | Granular | Granuler | | Granular |
| 15 | | | | 1 | +- | | j. | | _ | | | | ZIF. | <u> </u> | TIN S | | | | | | | | | 7!N | Fire of | | N 6.3 |
| | | | Outer Layer | Crystal | | a: 100 | - | | α:1001 | | α: 1004 | | a: 1001 | _ | K: 401 | | a: 1001 | | K: 401 | 1001 | 2001:3 | 001.004 | | a: 1001 | α: 1001 | - | G: 1001 |
| 20 | | | ğ —— | Contro | A1203 | A129 | 12.81 | (2.2) | A1203 | | A1203 | 2 | A1203 | ? : | A1203 | | A1203 | 6 | A1203 | 1,0,14 | 12.61 | A1203 | -4 | 6.53 | A1201 | - | 0.81 |
| | 7 | | Second Intermediate Layer | Crystal Struc- | Oranular | | | Granular | Oranular | | Granular | | Granular | | Granular | | Granular | 1 | Granutae | | Granular | +- | ci emoja c | Granular | Granular A | | Granuler |
| <i>25</i> | TABLE 1 Leyer | | Inte | Compo- of t 10n | TICNO | TICNO | TICNO | 6.11 | 11CNO | | 11C0 | | 71.00 | | TICNO (0.1) | | TICNO (0.1) | 900 | | ┵ | | + | TICNO | _ | TICO (0.1) Gr | 2 | (0.2) Gr |
| | TABL Hard Coating Layer | | Intermediate | Crystal Struc. | Granular | Granular | Granular | | Granular | | Granular | | Granulae | 1 | Granular | _ | Granular | E | Granular | +- | | - | | | | - | |
| | d Coa | | Intermedi | Compo- | 7.C | - | + | - | 9.5 | +, | | | | | | \dashv | | 1 | | S. C. | | Crenular | + | Granular | Granuler | - | Granular |
| 30 | Har | + | | | +- | + | +- | | | -+ | 1.5 | _ | Tic 19.61 | _ | . E | | (2.9) | TiCN | : : | Tic | (2.4) | Tic | F F | 12.51 | 1.02 1.03 1.03 | Tic | = |
| 35 | | Inner Layer | | Orientation | (111) (2001 (220 | 1220) (200) (1111) | (111) (200) (220) | | (200) (220) (111) | | 111111200112201 | | (220) (200) (111) | | (200) (220) (331) | | (1111)(2001(220) | | (111) | 111111200112201 | | 1320) (200) (1111) | | 111700112201 | 122011200111111 | 13111130011330. | |
| | | Inner | | Crystal Struc. ture | Granuler | Granuler | Granular | | Granular | | Granular | | Granular | 1 | Granular | 1 | Granular | | | Granuler 11 | 1 | Cranuler 12 | Connetee | - | | + | |
| | | | | Comps. Bition | TiCN (6.0) | TICN (3.2) | Ticn (9.3) | | | | 7.7 | | TICN 64 | TiCN | | 2 | (3.4) | - | | | | | + | - | Granitar | Crember | |
| 40 | | ١ | 7 | | Granular | _ | | | | | | + | | | | F | | TiCs | | F 5 | | . S. S. | | F | | F : C | |
| | | Innermont | ž | ton Struc- | | N Granulat | S) Granular | 3 | | - | - Cranting | 1 | Granulae | 1 | Cremular Cremular | | Granular | Cramatar | | Granular | | Granular | Granulas | | Granular | Granulas | |
| 45 | _ | L | | day. | F 0 | , 6 5 6 | 71.CN | 137 | 3.5 | 7.12 | <u>=</u> = | į | | 71.7 | (0.8) | Tin | (0.5) | Z i | | 71CN | 5 | 10.31 | 2 . | Z ;;- | 10.41 | Tik. | 6 |
| | ġ | Symbol | | | _ | | < | - | | a | _ | | , | U | | | | ٥ | 1 | ٥ | 1 | | iu iu | 6 | | U | \exists |
| | | ž | | - } | £ . | 8 | 57 | e a | | 8. 0. | | 9 | | = | | 26 | | 2 | 1: | , , | 2 | | 56 | 37 | | 96 | \dashv |
| 50 | | **!\f | | | | | | | | 1 | Cemented | Carbide | Cutting. Tools of | Prior Art | | | | | | | -4 | | | | - | | |

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TABLE 18 (a)

| | | | Porth Divided Lane | | or Crystel | 4 | Liongated Growth | | | | | | | | | | | | | | T | | Growth Growth |
|--------------------|-------|-------------|---------------------|----------------------|------------|---------------------|---------------------|-----------|-------------------|---------------------|---------------|-----------|---------------|---------------|--------|---------------------|---------------------|-----------|----------|---------------------|---------------------|---------------|---------------|
| | | | \vdash | + | aition | +- | 2. | 4 | | | \downarrow | - | | 1 | | | | | | | | TiCN | 17.71 |
| | | | Third Dividing | 2,00 | | Granit | | | | | | | | | | | | | | | | | Gramular |
| | | | | | e ic in | Tin | 2 | | | | | | | | | | T | 1 | 1 | | | | (0.2) |
| | | ľ | Third Divided Layer | | Structure | Slongated | Growth | | | | Elongated | Growth | | | Growth | | Elongated | Groveh | Growth | | - | - | Growth |
| | | | mira | å | sition | TICN | | | | | Tich | 9 | | TiCN | (2.8) | | Tick | J.C. | 2.4 | | \vdash | +- | (1.9) |
| DVer | , | Inner Layer | Second Dividing | Crystal | Struc | Granular | | | | | Granular | | | | a unum | | Granuler | Gramiler | + | | | Granular | |
| Hard Coating Laver | | Ę | Secon | Compo | alt los | Tin (0.2) | | | | | Tin | | | Tin | ê | | 1 in | + | (2.2) | | - | zi. | |
| Hard Co | | | Second Divided | Crystal | Structure | Elongated | Elongated | Growth | Growth | Elongated Growth | Elongated | Growth | Crowth Growth | Floodered | Growth | Slongated Growth | Elongated | Flongeted | Growth | Elongated Growth | Elongated | +- | |
| | | | Beco | | 11119 | TiCN (2.4) | S C | Tick | (3.1) TiCN | (3.0) | 71CN (2.7) | - FICN | (2.3) | TiCN | i N | (4.8) | TICN (0.8) | Ni C | + | - | 11.02 | 71.0N | 4 |
| | | | First Dividing | Crystal | ture | Granular | Grenular | Granuler | | oranolar | Granular | | of anular | Granular | | Granular | Granular | Granular | | Granular | Granular | Granuler | Granuler |
| | İ | | Ш | Compo- | | (0.3) | TiN (0.2) | ric | Tis vit | ? e | (0.2) | Ni. | (0.3) | Tin | + | _ | 0 - 1 in | Z (2.0) | | _ | 7 in (0.2) | 1 N T O | TiN (0.2) |
| | | | First Divided Layer | Crystel Structure | | Elongated Growth | Elangated | Elongated | Growth Florder ad | Growth | Elongated | Elongared | Growth | Elongated | Crowth | Grewth | Elongated Growth | Blangeted | +- | Granth | Flongated Greath | Elonget ed | 1 |
| | | | First D | Compo- | 1000 | (2.4) | TiCN (3.0) | TICN | TiCN | | (2.7) | TiCN | (7.7) | TiCN (3.4) | 4- | -+ | Z (1) | 7:CN | +- | + | 11.23 | TiCN (2.0) | TiCN (3.4) |
| | | Innermost | | Crystal Struc- | ture | Granular | | Granuler | Granular | | | Granular | | Cranular | | | Cremiar | Gramalar | Granular | -+- | Granular | Granuler | - |
| |] | Ę . | | Compo- | į | (1.0) | | 7 in | Tin | | | Tic. | ÷. | TiN (1.6) | | , | ا ۾ ر | Z G | + | | _ | 7.C2 (0.6) | |
| | £ 1.0 | Symbo. | | | < | | < | 4 | < | - | , | 9 | T | rs c | U | , | - | U | ٥ | - | - | ٥ | ٥ |
| | Type | 1 | | | 66 | | 3 | 101 | 707 | 103 | | 5 | | 6 | 901 | è | | | 103 | 110 | | | 21 |
| | | : | , | | | | | | | | Cented | Curcing | the | wot juster | | | | | | | | | |

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| | 1 1 1 1 |)} | Deep-cut Cutting | | | 0.20 | 0.18 | | 0.19 | 0.22 | | 0.17 | 0.16 | | 0.21 | 0.20 | 0.23 | | | 0.22 | 0.19 | | 0.17 |
|--------------------|------------|---------------------------------|----------------------|--------------------|--------------------|-------------------|-------------------|-------|-------------------|--------------------|---------|---------------------|-------------------|---------------|-------------------|-------------|-------------------|--------------------------------|-----------|-------------------|-------------------|-------|-------------------|
| | Flank Wose | (uu) | High-feed Cutting | 0.15 | | 0.16 | 0.17 | | 0.21 | 0.16 | | 0.15 | 0.20 | | 0.20 | 0.24 | 0.19 | | | 0.15 | 0.16 | | 0.16 |
| | | Outermost Layer | Crystal | ture | Granular | Granuler | Granular | | Granular | | | Granuler | | | Grenuler | - | | Ceanular | _ | | 1 | 1 | Granuler |
| | | Out | Compo- | TIN | (0.2) | (0.2) | TiCN- | (0.6) | TIN | 3.2 | | Tin | | | 71N (0.2) | | rin | | | - | + | 1 | Tin (0.2) |
| | • | Outer Layer | Crystal Structure | K:948 | | K: 1008 | K:1008 | | K:738 | K:1008 | | K: 731 | K:558 | | K: 85 | K: 62% | X: 941 | K.7.78 | | K: 628 | X: 1008 | 1 | K: 738 |
| Laver | | Oute | Compo- sition | A1203 | (2.5) | (2,2) | A1203 | | A1203 | A1203 | (3.4) | A1203 | A1203 | 0.2 | (1.5) | A1203 | A1203 | 41 ₂ 0 ₃ | (5.2) | A1203 | A1203 | 12.8) | (4.3) |
| Hard Coating Layer | | Second Intermediate Layer | Crystal Struc- | Granular | | Granular | | | | Granular | | Granular | Granular | | Granular | Granular | | | it amuler | | | + | |
| Hard | | Se Inter | Compo- sition | TiCNO | TICNO | (0.1) | | | | Tico | | TiCNO (0.1) | Tico | + | _ | TiCNO (0.1) | | | = | | - | + | \dashv |
| | | First Intermediate Layer | Crystal Struc- | | | Granular | Granular | | Granular | | | Granular | | | | Granular | | İ | 1 | Granular | - | | Granular |
| | | Inter | Compo- sition | | Tic | (3.0) | (1.9) | J. F | (3.0) | | 9 | (3.8) | | | | 1.8. | | | 200 | - F. C. | | - | (1.2) |
| | | Inner Layer | Orientation | (1111) (220) (200) | 19905, 1111, 10551 | (200) (111) (200) | (111) (220) (200) | | (111) (200) (220) | (1111) (220) (200) | | (111) (200) (220) | (111) (220) (200) | .030111111000 | 10071 (111) (011) | (1111) | (111) (220) (200) | (1111) (220) (200) | ╁ | (220) (111) (200) | (111) (220) (200) | +- | (111) (220) (200) |
| | Sub- | Symbo) | | ∢ | 4 | ~ | | < | | <u>m</u> | - | , | ω | U | 1 | | υ | ٥ | | | ۵ | 0 | |
| | | Туре | | 66 | 100 | 101 | | 707 | | - | 104 | | 507 | 106 | 267 | | 109 | 63 | 977 | | = | 211 | |
| | | È | | | | | | | | Coated | Carbide | Cutting Tools of | Invention | | | | | | | | | | |

TABLE 19 (a)

| | \neg | _ | _ | $\overline{}$ | | | | | | | | | | | | | | | | | | | | |
|--------------------|-------------|---------------------|-------------------------|----------------------|----------------|-----------|---------------------|---------------|---------------|---------|---------------------|---------------------|----------|--------------|---------------------|--|---------------------|--------------|----------------------|---------------------|--------------|----------|---------------------|--------------|
| | | | Forth Divided Layer | Crysta] | Structure | Elongated | Greeth | | | | | | | | T | | | | Clumpates Gruntl. | | - | | - | T |
| | | | Forth | Compo | sition | 71CN | | | 1 | | | 1 | | | + | | \dagger | NO.E | 10.71 | | + | - | | + |
| | | | Third Dividing | Crystel | Struc- ture | | | | | | | 1 | | | 1 | | \dagger | | Cramiler | | \dagger | 7 | | \dagger |
| | | | Third | 3/ | 8121 | | | \dagger | \dagger | _ | | + | _ | - | + | | | | (0.2) Gr | | + | \dashv | | + |
| | | | Third Divided Layer | Crystal | princeure | | | Florograd | Growth | | Clongatod | † | | longated | Groveh | | | | - | | | + | | + |
| | | | Third Di | Compo | | | | TiCN | | | 7iCN | \dagger | | TiCN | | | - | | (0.6) | | + | + | | \vdash |
| er | Inner Lavor | 1 de 1 de 1 | Second Dividing | Crystal | ture | | | Granular | | 1 | Granular | \dagger | | Granular | + | | | Granular | - | | | + | _ | |
| cing Lay | Inne | | Second | Compo- | | | | Nit | | 1 | (0.1) | \dagger | - | 718 (0,2) | ᅪ | 1 | | rin c | + | | \vdash | + | | _ |
| Hard Coating Layer | | | Second Divided Layer | Crystal Structure | | Groveh | Elongated Growth | Elongated | Flongated | Growth | Elongated Growth | Elongated | Growth | 70 | Growth Elongated | Growth | Elongsted | ┪- | + | Elongated Growth | Elongated | Growth | Elongated Growth | Elongated |
| | | | Secor | Compo- sition | Tich | (1.5) | TiCN (1.0) | TICN (2.0) | TiCN | 200 | 1.1 | S E | 70.5 | (0.8) | TICN | | (2.0) | TiCN | +- | (1.3) | T1CN (1.7) | + | | 71Cx |
| | | 10 10 10 | Layer | Crystal Struc- | Granular | | Granular | Granuler | Granuter | | Granuler | Granular | Ī | Granular | Gramuler | | Granuler | Granular | | - | Granular | ┰ | Granular | Granular |
| | | | | Compo- sition | Tin | (0.7) | 7iN (0.1) | TiN (0.2) | Tin (0.3) | Tin | (0.2) | Tin 10.21 | N.T. | _ | Tin | 2 | | Tin (0.2) | ┰ | | Tin (0.1) | ┰ | _ | Tin 10.21 |
| | | First Devided Lavar | | Crystal Structure | Elongated | Growth | Elongated | Elongated | Elengated | 1000 | Elongated Grouth | Elongated | crown | Growth | +- | 2000 | Elongated Growth | - | +; | -+ | Elongated (| + | _ | Elongaces |
| | | First | | Compo- sicion | TiCN | | (6.9) | TiCN (1.9) | TiCN (2.2) | NOIF | 11.11 | TiCN (3.4) | 4- | (1.1) | TiCN (1.7) | Tich | _ | TiCN (1.0) | | + | 11.0N | ├- | -4- | 2.5. |
| | Innermost | Ja/Ar | | Crystal Struc- | Granuler | | Granular | | | | Pinnos | | | Cramelar | | T | | Cramilar | Granular | | Granular | | 7 | Granular |
| | Ing. | | | Compo- aition | TiN (0.4) | i. | 71.C | | | Tic. | 7.iv (0.9) | | Tin | - | | | 1 | TiC# | NI C | - | (0.3) | | ا ا | (0.7) |
| -qng | Symbol | | | | tı. | | | ۲. | L. | U | | U | U | | U | U | | ω | ш | | , | ω. | i. | |
| | | | | | = | Ë | | = | 116 | Ξ. | 1 | : | <u> </u> | | 02. | 121 | | 777 | 121 | Ī | \neg | <u>.</u> | 12. | |
| | Type | | | | | | | — <u> </u> | | <u></u> | | Cutting Tools of | _ | | | <u>. </u> | | | - | ഥ | | | 1- | |
| | | | | | _ | _ | | | | | 000 | . 0 2 | 5.5 | | <u> </u> | | | | | | | | | |

0.20 0.21

0.12

Granular

TiN (0.3)

0.24 0.20 0.19

9. 0.15 0.14

Granular

Tin (0.4) TiN (0.5)

Granuler

0.14 (Milling) 0.15 (Milling)

r. Granular

Tin (0.3)

0.15 (Milling) 0.14 (Milling)

Granular

TiN (0.2)

(Milling)

0.14

Granular

TiN (0.2)

0.18 0.19 0.25

0.14 0.12 9.5

> Granular Granular

TiN (0.2)

Crystal Struc-ture

Compo-sition

Outermost Layer

Type

Flank Wear Ē

10

15

| | | i | | | | 1 | _ | | + | | + | - | | | | | | L | .1. |
|----|-------|--------------|-------|---------------------------------|---------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--------------------|-------------------|-------------------|--------------------|-------------------|-------------------|
| 20 | (q) | | | . Layer | Crystal Structure | K: 1008 | K: 948 | K: 1008 | K: 948 | K:558 | K:948 | K: 628 | K:858 | K: 1008 | K: 948 | K:1008 | K:100% | K: 100% | K: 948 |
| 25 | 19 | 100 | Layer | Outer | Compo- sition | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 |
| | TABLE | Hard Coaring | | Second Intermediate Layer | Crystal Struc- | Granular | Granular | | | Granular | Granular | | Granular | | | Granular | Granular | | Granular |
| 30 | | Hard | Die | S. Inter | Compo- sition | 7iC0 | TiCNO (0.2) | | | TiCO (0.1) | Tico (0.1) | | TiCNO (0.1) | | | TicNO (0.1) | TiCNO (0.1) | | TiCNO (0.2) |
| | | | | First Intermediate Layer | Crystal Struc- ture | Granular | | Granular | | | | Granular | Granular | | | Granular | | Granuler | |
| 35 | | | | Inter | Compo- sition | TiCN (1.4) | | 11.17 | | | | Tin (1.1) | TiC (2.9) | | | Tic (1.4) | | TiCN (0.8) | |
| 40 | | | | Inner Layer | Orientation | (220) (111) (200) | (111) (220) (111) | (111) (220) (200) | (111) (200) (220) | (111) (220) (200) | (220) (111) (200) | (220) (200) (111) | (111) (220) (200) | (220) (1111) (200) | (111) (220) (200) | (220) (111) (200) | (1111) (220) (200) | (220) (111) (200) | (111) (220) (200) |
| 45 | | | -qns | Symbol | | Ľ. | íu, | î. | i. | U | U | υ | U | ပ | ស | ω | ы | ū | ŭ |
| | | | | 61 | | | 7. | 115 | 116 | 711 | 118 | 119 | 120 | 121 | 122 | 123 | 124 | 125 | 126 |

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Coated Committed Carbide Cutting Tools of the Invention

TABLE 20

| | Moore | 1 | | | 0.53 (Chipping) | 0.52 | 0.43 | (cutpping) | 0.57 (Chipping) | 0.60 (Chipping) | 0.39 (Chipping) | | 21.6 min. due | Separation | Feilure after 20.8 min. due | Separation | Failure ofter | Separation | Feilus efter | to Layer | 3 | Chiming | failu.e after | to frecturing | Failure after 5.9 min. due | Failure effer |
|--------------------|--------------|--------------------------------|-------------------|----------------|---------------------------------|-------------------|-------------------|-------------------|--------------------|--------------------|--------------------|-------------------|---------------|------------|--------------------------------|------------|---------------------|------------|--|-----------|-------------------|---------|--------------------|---------------|-------------------------------|-------------------|
| | Plank Wear | (man) | | | 0.57 (Chipping) | 0.61 | 0 . 59 Chimina | 000 | (Chipping) | 0.64 (Chipping) | 0.59 (Chipping) | ٦, | | \neg | Feilure ofter Fe | -1 | ger. | _ | Failure after Fai 19.5 min. due 20. | | 1 | | Failure atter Fail | \neg | | _ |
| | | Outermost Layer | _ | Struc. ture | Granular | Gramler | Granular | | Granular | | Granular | | | | Granular | | | 38 | Granuler 1 | . J. J. | | | 2 = | | 23 | Granuler 11 |
| | | 3 | 8 | 7 | (0.2) | Tin | TICN | 0 Z | ŝ | | 1 (0.3) | | | | 7 in | | | | Nit o | | | | | 1 | | zir c |
| | | Outer Layer | Crystal | ture | α: 100) | a:1001 | K: 401 | 1001 | | a: 1001 | a: 1001 | 4.100 | | | a:1001 | | K: 404 | | α:1001 | | α: 1001 | 1 | α: 1001 | 1 | a: 1001 | α:1001 |
| | | - | Compo | | (2.3) | A1203 | A1203 | A1201 | (2,5) | (3.4) | A1203 | 11201 | (3.2) | 1 | (1.6) | 3 | 6.9 | | A1203 | 16.3 | A1203 (| - | _ | - | (5.5) | + |
| | | Second Intermediate | Crystal | ture | Granuler | Granuler | | | | Granuler | Granuler | | Granular | | Gramler | | Gzanuler | | | | Gramular | + | _ | | - | |
| yer | | Inte | Compo- | CNO | 0.13 | Ticko (0.1) | | | 9 | 9.7 | TiCNO (0.1) | rico | - î | TiCo | | TiCNO | | † | | | TICNO | | _ | \dagger | | |
| Hard Coating Layer | | First Intermediate Layer | Crystal Struc- | ture | _ | Granular | Granular | Granular | | | Granular | | | | | | Granular | 1 | | 1 | | 1 | Granular | \dagger | _ | Granular |
| Hard Co | | Inter | Compo- sition | | 1 | (2.8) | TiC (2.0) | Tic | ē | | 71C (3.6) | \dagger | | | | Tin | (1.8) | \dagger | | \dagger | _ | TICN | | \dagger | - | Tic (1.3) Gr |
| | | Inner Layer | Orientation | | (277) (200) (777) | (220) (200) (1111 | (1111 (200) (220) | (200) (220) (111) | | (111) (200) (220) | (220) (200) (1111) | (200) (220) (111) | | | 1022) (2001) (111) | +- | (1111) (2021) (272) | | (111) (200) (230) | + | (111) (002) (072) | ┿ | (111) (300) (320) | | (220) (200) (1111) | (311) (200) (320) |
| | | Inner | Crystal Struc- | in a | | Gramular | Granular | Granular | | Cramuler | Granular | Gramler | | | and and | | | _ | Granular | + | Gramlar | +- | ranniar | ⊢ | | Granular (|
| | | | Compo- sition | Ti C | 2 1 1 1 1 1 1 | (6.1) | (9.3) | TiCN | Tich | (8.4) T(C) | (6.6) | TICN | | Tich | (9.8) | - | (S. S) | +- | (7.7) | 7.CN | | ₩- | (5.4) | - | -+ | (6.9) |
| | | Layer | Crystal Struc- | Granular | | | Granular | Gramular | | | Granular | Granular | | | | Granular | | | | +- | Granular | 1 | - | Gramitar | -+ | |
| L | \perp | | Campo- | rin | 3 | į | (0.6) | TiN (0.5) | | TiC. | TiN (1.5) | Tin (1.7) | | | | Tic | | z | 15.0) | Tin | (9.0) | ┢ | (0.7) | _ | 6.9 | |
| _ | Sub- | Symbol | | 4 | < | - | | 4 | | - | | c) | | u | | U | | U | | - | | ٥ | | _ | 6 | |
| | Type | | | 66 | 100 | = | _ | 707 | ē | ğ | | 501 | | \$ | | 103 | | 108 | | 601 | | 110 | | = | | |
| | <u>م</u> | | | | | | • | | | Costed | Carbide | Frior Art | | | | | | | | | | | | | | |

| 5 | | Plank Wear (mm) | interruped cutting | Failure after 8.0 min. due | Feilure after 7.6 min. due to Frecturing | Failure after 3.3 min. due to Fracturing | Failure after 6.3 min. due to Fracturing | Failure atter 5.8 ain. due to Fracturing | Failure after 4.5 min. due to Fracturing | Failure after 7.4 min. due | Failure after 7.9 min. due to Frecuring | Failure after 5.2 min. due to Frecturing | (Chipping) | Ippingl | ippingl | lpping! | pping) |
|----|--------------------------------|---------------------------------|---------------------------|--------------------------------|--|--|--|--|--|--------------------------------|---|--|-------------------|-------------------|-------------------|-------------------|-------------------|
| 10 | ; | Plan (i | Continuous Cutcing | Failure after 13.6 min. due | Failure after 16.0 min. due to Chipping | Failure after 14.4 min. due to Layer | Failure efter 15.1 min. due to Layer | Fellure after 17.4 min. due to Chipping | Fallute after 16.3 min. due to Layer | Failure after 12.5 min. due | i g | 5 8 | O.41 (Chipp | 0.37 (Chipping) | 0.33 (Chipping) | 0.38 (Chipping) | 0.36 (Chipping) |
| | | Outermost Layer | Crystal Struc- | Granuler | Grenuler | | Granular | | Gramuler | Gramler | | | Granular | | Granuler | | Gramular |
| 15 | | 8 | Compo- sition | TiN (0.2) | TÍN (0.2) | | TIN (0.0) | | Tin (0.4) | TiN (0.5) | | | NIT O | | 7 in | | Tin (0.2) |
| | | Outer Layer | Crystal Struc- | | α:1001 | K: 401 | α: 1001 | a:1001 | a:1001 | K: 401 | a: 1001 | K: 401 | 1001:0 | α:1001 | a: 1001 | a: 1001 | a: 1001 |
| 20 | | Oute | Compo- sition | A1203 | A1203 | A1203 (1.5) | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | A1203 | 1203 | 1,20 |
| | | Second Intermediate Layer | Crystal Struc- ture | Granular | Gzenuler | | | Granular | Granular | | Granular | | | Granuler | Granuler | | Gzenuler |
| 25 | er | Se Inte | Compo- sition | 7ico (0.1) | TiCNO (0.2) | | | Tico (0.1) | TiCo (0.1) | | Ticno (0.1) | | | TiCNO (0.1) | TiCNO (0.1) | | TiCNO (0.2) |
| | TABLE 21 Hard Coating Layer | Pirst Intermediate Layer | Crystal Struc- ture | Granular | | Granular | | | | Granuler | Granular | | | Granular | | Granulae | |
| 30 | Hard Co | Inter | Compo- sition | T1CN (1.5) | | TiCN (1.2) | | | | Tin (1.8) | T1C (2.8) | | | Tic (1.5) | | TiCN (0.9) | |
| 35 | | Layer | Orientation | (111) (200) (220) | (220) (200) (111) | (111) (200) (220) | (200) (320) (111) | (1111) (200) (220) | (111) (200) (111) | (200) (220) (111) | (111) (200) (220) | (270) (200) (111) | (111) (200) (220) | (220) (200) (111) | (111) (200) (110) | (111) (300) (311) | 11111 (200) (220) |
| · | | Inner Layer | Crystel Struc- ture | Granuler | Gramler | Granuler | Gramiar | Cranuler | Granular | Granuler | Granular | Granuler | Granulae | Granular | Gramular | Granular | Granular |
| 40 | | | Compo- sition | TiCN (3.2) | TiCN (2.1) | TiCN (6.5) | TiCN (4.6) | TiCN (3.5) | TiCN (7.0) | 1.CN | TiCN (3.3) | TiCN (4.5) | TiCN (3.2) | T1CN (2.6) | TiCN (3.5) | TICN (3.0) | TiCN (2.9) |
| | | Innermost Layer | Crystal Struc- ture | Granular | Granular | | | Granular | | Granular | | | Granular | Granular | Granutar | | Granular |
| 45 | | let J | Compo- sition | (0.3) | TiCN (0.9) | , | | Tic- Tin (1.0) | | Tin (0.6) | | | TiCN (0.51 | 1iv (0.3) | 4iv (0.3) | | ric (0.81 |
| | | Symbol | | ۲. | tu. | æ | tu. | v | U | o | v | υ | ı | ω l | ia) | | ù |
| | | • | } | | | ž. | | £ | =: | 2 | 3 | 2 | ≊ | 2 | · | <u> </u> | 2 |
| 50 | | Туре | | | | | | | Carbide Carbide Cutting | Prior Art | | | | | | | |

Claims

- 1. A coated hard alloy blade member comprising a substrate formed of a hard alloy selected from the group consisting of a WC-based cemented carbide and a TiCN-based cermet, and a hard coating deposited on said substrate, said hard coating including an inner layer of TiCN having unilaterally grown crystals of an elongated shape obtainable 5 by a two-step deposition process wherein a first coating of TiCN is formed using a CVD gas for TiCN deposition comprising acetonitrile having a concentration of acetonitrile gas from 0.01 to 0.1 vol % and a second coating of TiCN is formed using a CVD gas for TiCN deposition comprising acetonitrile wherein the concentration of acetonitrile is increased to be from 0.1 to 1.0 vol % and an outer layer of Al203 having a crystal form of κ or κ + α , 10
 - 2. A coated hard alloy blade member according to claim 1, wherein the substrate is formed of a WC-based cemented
- 3. A coated hard alloy blade member according to claim 1 and/or 2, wherein the TiCN in said elongated crystals of said inner layer has X-ray diffraction peaks such that strength (200) plane is weak compared to strengths at (111)
- A coated hard alloy blade member according to any one of the preceding claims wherein said hard coating further includes an innermost layer of one or more of granular TiN, TiC, or TiCN formed underneath said inner layer. 20
 - 5. A coated hard alloy blade member according to any one of the preceding claims, wherein said hard coating further includes an outermost layer of one or both of granular TiN or TiCN formed on said outer layer of Al₂O₃.
- 6. A coated hard alloy blade member according to any one of the preceding claims, wherein said hard coating further 25 includes a first intermediate layer of one or more of granular TiC, TiN, or TiCN formed between said inner layer of TiCN and said outer layer of Al₂O₃.
- 7. A coated hard alloy blade member according to any one of the preceding claims, wherein said hard coating further includes a second intermediate layer of one or both of TiCO or TiCNO formed between said inner layer of TiCN and 30 said outer layer of Al2O3.
 - 8. A coated hard alloy blade member according to any one of the preceding claims, wherein said inner layer of TiCN further includes one or more layers of TiN such that the inner layer is divided by the layers of TiN.
 - A coated hard alloy blade member according to any one of the preceding claims, wherein said WC-based cemented carbide consists essentially of 4 - 12 % by weight of Co, 0 - 7 % by weight of Ti, 0 - 7 % by weight of Ta, 0 - 4 % by weight of Nb, 0 - 2 % by weight of Cr, 0 - 1 % by weight of N, and balance W and C.
- 10. A coated hard alloy blade member according to claim 8, wherein the maximum amount of Co in a surface layer of the substrate ranging up to 100 μm depth from a surface thereof is 1.5 to 5 times as much as the amount of Co in an interior 1 mm deep from the surface.
- 11. A coated hard alloy blade member according to any one of the preceding claims, wherein said TiCN-based cermet consists essentially of 2 - 14 % by weight of Co, 2 - 12 % by weight of Ni, 2 - 20 % by weight of Ta, 0.1 - 10 % by 45 weight of Nb, 5 - 30 % by weight of W, 5 - 20 % by weight of Mo, 2 - 8 % by weight of N, optionally no greater than 5 % by weight of at least one of Cr, V, Zr or Hf, and balance Ti and C.
- 12. A coated hard alloy blade member according to claim 11, wherein hardness in a surface layer of the substrate ranging up to 100 µm depth from a surface thereof is more than 5% harder than hardness of an interior 1 mm deep from 50
 - 13. The use of a hard coated blade member according to any one of the preceding claims in cutting tools.

Patentansprüche

1. Beschichtetes Hartlegierungs-Klingenelement, umfassend:

ein Substrat aus einer harten Legierung, ausgewählt aus auf WC basierendem Sinterkarbid und einem auf TiCN basierendem Cermet,

und eine harte Beschichtung abgeschieden auf dem Substrat, die harte Beschichtung schließt eine innere Schicht aus TiCN ein, die unilateral gewachsene Kristalle mit gestreckter Form aufweist, erhältlich durch ein zweistufiges Abscheidungsverfahren, worin eine erste TiCN-Beschichtung durch Verwenden eines Acetonitril umfassenden CVD-Gases für die TiCN-Abscheidung gebildet wird, das Acetonitrilgas in einer Konzentration von 0,01 bis 0,1 Vol.% besitzt, und eine zweite Beschichtung aus TiCN durch Verwenden eines Acetonitril umfassenden CVD-Gases für die TiCN-Abscheidung, worin die Konzentration von Acetonitril auf 0,1 bis 1,0

eine äußere Schicht aus Al $_2$ O $_3$, die eine Kristallform von κ oder κ + α aufweist, worin κ > α ist.

- Beschichtetes Hartlegierungs-Klingenelement nach Anspruch 1, worin das Substrat aus einem auf WC basieren den Sinterkarbidsubstrat gebildet wird.
 - Beschichtetes Hartlegierungs-Klingenelement nach Anspruch 1 und/oder 2, worin das TICN in den gestreckten Kristallen der inneren Schicht Röntgen-Diffraktionspeaks aufweist, deren Intensität für die (200) Ebene schwach ist im Vergleich zur Intensität für die (111) und (220) Ebenen.

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- Beschichtetes Hartlegierungs-Klingenelement nach mindestens einem der vorhergehenden Ansprüche, worin die harte Beschichtung weiterhin eine innerste Schicht, die aus k\u00f6rnigem TiN, TiC oder TiCN oder mehreren gebildet wird, unterhalb besagter inneren Schicht einschlie\u00dft.
- 25 5. Beschichtetes Hartlegierungs-Klingenelement nach mindestens einem der vorhergehenden Ansprüche, worin die harte Beschichtung weiterhin eine äußerste Schicht, gebildet aus k\u00f6rnigem TiN oder TiCN oder beidem, auf der \u00e4uber 203 einschlie\u00e4t.
- Beschichtetes Hartlegierungs-Klingenelement nach mindestens einem der vorhergehenden Ansprüche, worin die harte Beschichtung weiterhin eine erste Zwischenschicht aus körnigem TiC, TiN oder TiCN oder mehreren davon zwischen der inneren Schicht aus TiCN und der äußeren Al₂O₃-Schicht einschließt.
- Beschichtetes Hartlegierungs-Klingenelement nach mindestens einem der vorhergehenden Ansprüche, worin die harte Beschichtung weiterhin eine zweite Zwischenschicht aus TiCO oder TiCNO oder beiden zwischen der inneren Schicht aus TiCN und der äußeren Al₂O₃-Schicht einschließt.
 - Beschichtetes Hartlegierungs-Klingenelement nach mindestens einem der vorhergehenden Ansprüche, worin die innere Schicht aus TiCN weiterhin eine oder mehrere Schichten aus TiN einschließt, so daß die innere Schicht durch die TiN-Schichten geteilt ist.
 - Beschichtetes Hartlegierungs-Klingenelement nach mindestens einem der vorhergehenden Ansprüche, worin das auf WC basierende Sinterkarbid im wesentlichen aus 4 - 12 Gew.% Co, 0 - 7 Gew.% Ti, 0 - 7 Gew.% Ta, 0 - 4 Gew.% Nb, 0 - 2 Gew.% Cr, 0 - 1 Gew.% N und zum Rest aus W und C besteht.
- 45 10. Beschichtetes Hartlegierungs-Klingenelement nach Anspruch 8, worin die Höchstmenge an Co in der Oberflächenschicht des Substrats in einer Tiefe von bis zu 100 μm von der Oberfläche 1,5 bis 5-mal so groß ist wie die Menge an Co in einer inneren Schicht in einer Tiefe von 1 mm von der Oberfläche.
- 11. Beschichtetes Hartlegierungs-Klingenelement nach mindestens einem der vorhergehenden Ansprüche, worin das auf TiCN basierende Cermet im wesentlichen aus 2 14 Gew.% Co, 2 12 Gew.% Ni, 2 20 Gew.% Ta, 0,1 10 Gew.% Nb, 5 30 Gew.% W, 5 20 Gew.% Mo, 2 8 Gew.% N, optional nicht mehr als 5 Gew.% wenigstens eines der Elemente Cr, V, Zr oder Hf und zum Rest aus Ti und C besteht.
- 12. Beschichtetes Hartlegierungs-Klingenelement nach Anspruch 11, worin die Härte der Oberflächenschicht des Substrats bis zu einer Tiefe von 100 μm von der Oberfläche um mehr als 5 % härter ist als die Härte einer inneren Schicht in einer Tiefe von 1 mm von der Oberfläche.
 - 13. Verwendung eines hart-beschichteten Klingenelements nach mindestens einem der vorhergehenden Ansprüche in

Schneidewerkzeugen.

Revendications

- 1. Elément de lame en alliage dur à revêtement comprenant un substrat formé en un alliage dur choisi dans le groupe constitué par un carbure fritté à base de WC et par un cermet à base de TiCN, et un revêtement dur déposé sur ledit substrat, ledit revêtement dur comprenant une couche interne de TiCN ayant des cristaux d'une forme allongée formés unilatéralement, cette couche étant subsceptible d'être obtenue par un procédé de revêtement en deux étapes, dans lequel un premier revêtement de TiCN est formé en utilisant un gaz CVD pour dépôt de TiCN comprenant de l'acétonitrile ayant une concentration en gaz acétonitrile dans la plage de 0,01 à 0,1 % en volume et un 10 second revêtement de TiCN est formé en utilisant un gaz CVD pour dépôt de TiCN comprenant de l'acétonitrile dans lequel la concentration en acétonitrile est augmentée pour se situer dans la plage allant de 0,1 à 1,0 % en volume et une couche externe d'Al $_2$ O $_3$ ayant la forme cristalline κ ou κ + α , où κ > α .
- Elément de lame en alliage dur portant un revêtement selon la revendication 1, dans lequel le substrat est formé par un substrat de carbure fritté à base de WC.
 - Elément de lame en alliage dur portant un revêtement selon la revendication 1 et / ou 2, dans lequel le TiCN dans lesdits cristaux allongés de ladite couche interne a des pics de diffraction des rayons X, où la composante correspondant au plan (200) est faible par comparaison avec la composante correspondant aux plans (111) et (220).
 - 4. Elément de lame en alliage dur portant un revêtement selon l'une quelconque des revendications précédentes, dans lequel ledit revêtement dur comprend en outre une couche interne profonde en un ou plusieurs composés granulaires TiN, TiC ou TiCN, formée sous le couche interne.
 - Elément de lame en alliage dur portant un revêtement selon l'une quelconque des revendications précédentes, dans lequel ledit revêtement dur comprend en outre une couche externe de surface en TiN et /ou en TiCN granulaires formée sur ladite couche externe d'Al₂O₃.
- 6. Elément de lame en alliage dur portant un revêtement selon l'une quelconque des revendications précédentes, dans lequel ledit revêtement dur comprend en outre une première couche intermédiaire d'un ou de plusieurs composés TIC, TIN ou TiCN granulaires, formée entre ladite couche interne de TiCN et ladite couche externe d'Al₂O₃.
- 7. Elément de lame en alliage dur portant un revêtement selon l'une quelconque des revendications précédentes, dans lequel ledit revêtement dur comprend en outre une seconde couche intermédiaire de TiCO et/ou de TiCNO, 35 formée entre ladite couche interne de TiCN et ladite couche externe d'Al₂O₃.
- Elément de lame en alliage dur portant un revêtement selon l'une quelconque des revendications précédentes, dans lequel ladite couche interne de TiCN comprend en outre une ou plusieurs couches de TiN, de sorte que la 40 couche interne est divisée par les couches de TiN.
 - Elément de lame en alliage dur portant un revêtement selon l'une quelconque des revendications précédentes, dans lequel le carbure fritté à base de WC est constitué essentiellement par 4 - 12 % en poids de Co, 0 - 7 % en poids de Ti, 0 - 7 % en poids de Ta, 0 - 4 % en poids de Nb, 0 - 2 % en poids de Cr, 0 - 1 % en poids de N, le reste
 - 10. Elément de lame en alliage dur portant un revêtement selon la revendication 8, dans lequel la quantité maximale de Co dans une couche de surface du substrat allant jusqu'à 100 µm de profondeur depuis une surface de celui-ci est de 1,5 à 5 fois plus importante que la quantité de Co à l'intérieur, à 1 mm de profondeur, de la surface.
 - 11. Elément de lame en alliage dur portant un revêtement selon l'une quelconque des revendications précédentes, dans lequel le cermet à base de TiCN est constitué essentiellement par 2 - 14 % en poids de Co, 2 - 12 % en poids de Ni, 2 - 20 % en poids de Ta, 0,1 - 10 % en poids de Nb, 5 - 30 % en poids de W, 5 - 20 % en poids de Mo, 2 - 8 % en poids de N, le cas échéant pas plus de 5 % en poids d'au moins un des éléments Cr, V, Zr ou Hf, le reste
 - 12. Elément de lame en alliage dur portant un revêtement selon la revendication 11, dans lequel la dureté dans une couche de surface du substrat allant jusqu'à 100 μm de profondeur depuis une surface de celui-ci est supérieure

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par 5 % à la dureté à l'intérieur, à 1 mm de profondeur, depuis la surface.

| 5 | Utilisation d'un élément de lame en alliage dur portant un revêtement selon l'une quelconque des revendications précédentes pour un outil de coupe. |
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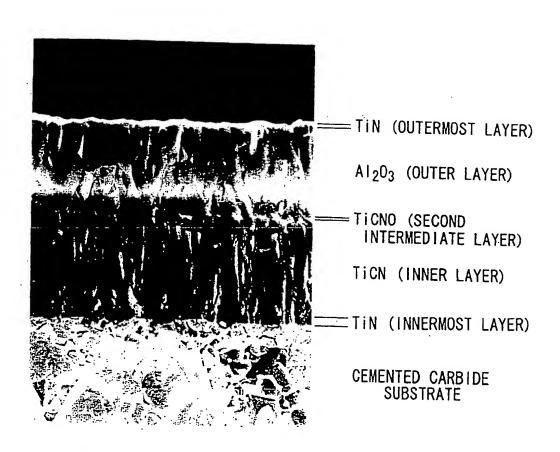


FIG. 1 COATED CEMENTED CARBIDE CUTTING TOOL "64"